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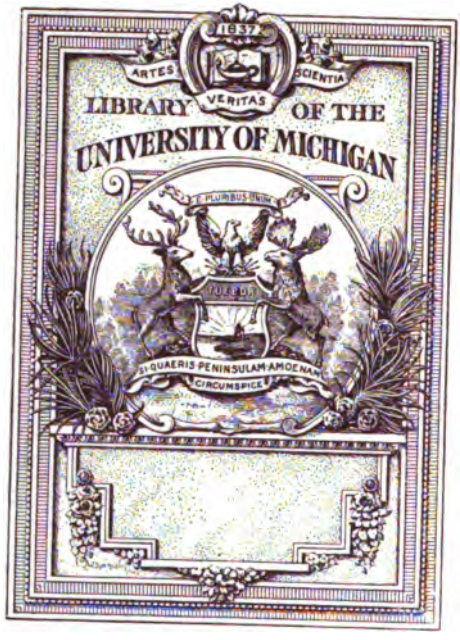
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THE WORLD'S GOLD

ITS GEOLOGY, EXTRACTION, AND POLITICAL ECONOMY

BY

L. DE LAUNAY

Professor in the École Supérieure des Mines

TRANSLATED BY

ORLANDO CYPRIAN WILLIAMS

WITH AN INTRODUCTION BY

CHARLES A. CONANT

Author of "History of Modern Banks of Issue," etc.

G. P. PUTNAM'S SONS

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INTRODUCTION TO THE ENGLISH VERSION

IN the slow evolution of monetary systems, gold has finally emerged as without dispute the metal best adapted for money in developed commercial countries. "The battle of the standards," waged bitterly within the memory of men still young, has ended with a triumph so complete that there is no longer pretender bold enough to dispute the sovereignty of gold. There may be question whether silver coins are not still preferable in large amounts for use in the undeveloped countries of the Orient, but even in those regions it is generally recognised that the monetary systems of the future must at least be based upon gold as the unit and standard of value.

It is significant of this evolution that a book should find a place in this scientific series which treats distinctively of gold as the money metal of civilised nations. It is a well-known fact that much of the gold which is now being poured into the monetary systems of the world could never have been extracted from the earth with profit under the old methods of production. Long ago, the alluvial deposits which made the fortunes of the Californian "forty-niners" and of the pioneers in Australia were to a large degree exhausted. The fear began to be harboured, even

among men of science, that the sources of supply of new gold were practically exhausted, and that, if the metal continued to be the sole standard of value, the commercial world would face the long, slow paralysis of steadily declining prices. Without discussing here whether such fears were likely to be verified in any case, it is enough to say that they were defeated by events. As in most human affairs, a great need developed the means for meeting it. In South Africa, and even in abandoned gold-fields of other days in California and other parts of America, were found quantities of gold infiltrated through quartz reefs, which would not amalgamate with quicksilver or yield to the older processes, but became suddenly available in immense quantities under the touch of the magic wand of modern methods of extraction. By these improvements, the entire face of the economic problem which confronted the world in the early nineties has been changed.

It is appropriate, therefore, now that the extraction of gold has been reduced to a scientific basis, that there should be a work discussing its scientific production. It is more important than under earlier conditions that the economist should take note of the technical aspects of gold production, which have heretofore been relegated chiefly to the mining engineer. It is one of the merits of this book of M. de Launay that it performs this service. While the task has been essayed before by a few scientific experts, like Shaler and Suess, it has not been attempted

upon a systematic basis since the recent improvements in the separation of ores and radical changes in methods of mining. M. de Launay examines the problem of the future supply of gold from the scientific standpoint and correlates the influence of this supply with prices and the movement of capital from the financial standpoint. Thus he performs the rare service of welding together the technical and economic aspects of the subject.

When the annual average production of gold was only $110,000,000 per year, as was the case from 1871 to 1890, the problem of the supply available for money was a very different problem from that which had to be solved when the annual supply rose to an average of $221,600,000 per year, as was the case from 1891 to 1902, and when it further advanced during the five years ending with 1907 to an average of $371,000,000 per year. Such figures, taken in the gross, indicate wide disparities in the supply of gold coming into the market, but when subtraction is made of the stock annually consumed in the arts the supply left available for use as money becomes even more variable.

It is probable that in 1890 about $60,000,000 in gold was consumed in the arts. The amount left available for use as money was about $50,000,000, —a sum absolutely insignificant when it became the prize for which many powerful nations contended. The consumption in the arts has steadily increased, until it was estimated by the Mint Bureau of the

United States for 1906 at $121,000,000; but upon the basis of the total production of that year, the amount left available for money was about $279,000,000, or more than five times the average of the years ending with 1890. A reasonable estimate puts the total production of gold for the seventeen years ending with 1907 at $4,515,046,000, from which consumption in the arts would subtract perhaps $1,700,000,000.[1] This would leave for addition to the world's monetary stock in the brief period of seventeen years about $2,800,000,000, while at the slow rate of progression of 1890 seventeen years would have added only about $850,000,000.

Important as have been these additions to the monetary stock, it is equally important, in view of the enormous expansion of modern commercial operations, that the new supply should not be fitful and uncertain, but should be constant and calculable. It is upon this phase of the subject that the work of M. de Launay throws much light. Where, prior to the successful working of the South African mines in the early nineties, there were grave fears that none but the strongest nations would be able to draw over themselves a part of that scanty blanket of gold which was the favourite simile of the bimetallists, it is now apparent that the blanket has been broadened many times and that a portion may fall to the share of even the humblest of the peoples which

[1] *Vide* estimates by the present writer in *A History of Modern Banks of Issue*, final chapter.

seeks its shelter by sound and honest monetary laws.

I shall not seek to discuss fully the question whether prices rise and fall with the quantity of gold. I shall content myself with expressing agreement with M. de Launay, that while the quantity of gold is one of the factors which influence prices, it is only one among many factors, several of which are powerful enough, either singly or in combination, to neutralise changes in the quantity of money. They reason by false analogies, therefore, who seek to establish direct mathematical relations between the increase or decrease in the world's stock of money and the rise or fall of prices.

Notwithstanding the uncertainties of the problem, however, it would probably be admitted by all but a few economists that the great increase in the supply of gold in recent years has tended to lubricate the wheels of commerce and to facilitate the adoption of the gold standard in one nation after another which has risen to the stature of commercial manhood. The theory that an increase in the supply of a commodity may operate in such a way as to distribute it laterally, so to speak, over territory where it had not previously gone, instead of superimposing it upon the stock in countries already supplied with a gold currency, is not inconsistent with opposition to the theory that prices rise and fall in direct and definite ratio to the supply of gold. Because the manufacture of more freight cars permits an adequate

supply of cars to be extended to the shippers of Manchuria, where formerly the supply was only adequate for European Russia, is far from being an affirmation that the price of freight cars has been lowered in the ratio of the increase in the supply of them.

For the older countries—Great Britain, France, Germany, and to some extent the United States—the supply of gold existing before 1900 would probably have served quite, or nearly, as well the purpose of their exchanges as the great increase of supply which has since partly found a resting-place in the vaults of their banks, but has partly also passed through these channels to other countries where the need of a gold currency was greater. It has been to those countries which lacked an adequate supply of gold that the outpour of hundreds of millions from the mines has brought the greatest benefits. It has enabled them to adopt the one sound and convenient tool of exchanges which has been evolved from the experience of centuries since the first employment of coined money. Russia, where hardly a ruble of gold was in circulation prior to 1895, now possesses nearly $600,000,000 and is a not distant competitor of France and America as the greatest holders of gold in the world. Russia adopted the gold standard finally and effectively in 1897. Japan, her rival in the struggle for power in the Orient, reached the same conclusion by independent means when she adopted the masterly report of Count Mat-

sugata, in which Count Sakatani had so large a part. Mexico and the Philippines have followed suit, and the important nations having dependencies in the Orient—Great Britain, France, and Germany—are planning to make gold the standard, if not the medium of circulation in their extensive possessions.

If there is any criticism to be pronounced upon our author's final analysis of the relation of the supply of gold to the future demand for it, it is in the failure to draw a sufficiently sharp line between the demand for gold and the demand for capital. It is in accordance with his own sobriety of view, that the great increase in the quantity of gold has not had a corresponding effect upon prices. It is not in accordance with economic reasoning, however, to attribute to the growing demand for new railways, new mills, and new machinery a corresponding outlet for new gold. While the demand for capital assumes at the banker's the form of a demand for gold, or for promises to pay gold, because gold is the generic form of free capital, it is not really gold which the capitalist requires; and it is not gold which is consumed. What he requires is rails, cars, building materials, iron and steel. It is these which he consumes; the gold or its paper promises only pass through his hands to those of other producers, surviving undiminished in amount to enter again upon their work of moving the products of the world.

A great increase in industrial activity undoubtedly increases the demand for currency for the purpose

of affording adequate tools for the multiplied volume of daily transactions; but this increase interprets itself in part by the expansion of credit, in part by the increased demand for the token coins of silver and copper which make up the smaller forms of money. Fundamentally, the activities of the industrial world rest upon the products of labour, and these activities might go on, increasing material wealth by uncounted millions, while the quantity of gold, the mere tool of exchanges, remained unaltered.

The decline in rates of interest about 1894 is rightly attributed by our author to conditions in the market for capital and not to increase in the stock of money. A large increase in bank reserves doubtless depresses rates for short-time loans and tends to foster speculation; but the permanent rate for the use of capital must depend ultimately upon the supply of capital in all its forms, of which gold is only one. If gold were depreciating rapidly in value in relation to other things, the theory which has recently found some favour among analytical economists might be realised —that the lender of capital would exact a higher rate for its use in order to cover the loss in its purchasing power when returned to him. Bonds in such a case would be a worse investment than stocks, because only a diminishing proportion of earnings would be required to meet fixed charges on bonds and the increment of increased earnings expressed in money would become available for maintaining

the real return upon the capital represented by stocks. But the judgment of our author accords with the sober sense of the financial world,—that the depreciation of gold is not likely to reach a point threatening disaster to the existing order, but, on the contrary, its exchange power in relation to other things will rise in view of the greater difficulty of obtaining it and the greater demand growing out of the expansion of the world's activities and of the area of banking development.

For the sufficiency of the gold supply in future and its substantial steadiness in value there is little reason to fear. Between extensive demand, stimulating to renewed research, and excessive supply, raising the cost of mining and reducing its relative profits, there is likely to be a rhythm established, not always acting instantly, but acting in time to prevent the revolution in prices and wages which has been feared by some of those who ignore the many and subtle causes of friction which defeat the operation of calculated laws.

Seductive as have seemed some of the projects for supplanting gold by paper promises or by agreements to accept such promises as the representatives of value, no such plan has yet succeeded, or is likely to succeed in our time or in the generations to come after us, because gold is the one article of merchandise which men will take in exchange for all others and which sits as arbiter and judge between all others.

If other articles retained a constant value in

relation to each other, then the dreams of those who advocate a universal credit money, in which certificates of commodities should exchange for each other, would come true. But it is precisely because the values of articles are constantly changing in their relationships to each other that credit money representing commodities must ever be subjected to the test of a standard of value. To declare that a bushel of wheat on a given occasion is the equal of ten pounds of cotton, and that therefore we can do away with money because we can exchange a certificate of wheat for a certificate of cotton, is to ignore the great part which gold plays as the register between wheat and cotton, when wheat becomes too plentiful and exchanges for less gold and less cotton, or when cotton becomes scarce and exchanges for more wheat and more gold. It is in holding the balance even, in establishing a common standard, that gold performs the great function of directing the division of labour into those channels where the largest gold returns afford the index that it is most productive. The attempt to substitute paper certificates or other commodities as a standard and measure of value would only lead to depreciation, confusion, bankruptcy, and the misdirection of labour.[1]

But the retention of gold as the standard does not preclude economy in its use. The extent of these

[1] For a more complete discussion of this subject, *vide*, in the writer's *Principles of Money and Banking*, the chapter, "Is an Ideal Money Attainable?", vol. ii., pp. 419–439.

economies M. de Launay has to some extent indicated. That Great Britain carries on her enormous trade with less gold in daily use to-day than in 1844; that clearings at New York in 1906 to the amount of $103,754,100,091 were settled with the use of only 3.69 per cent. in currency; that in the banks of Paris and the Seine 92.33 per cent. of currency payments are made in bank notes and only 7.67 per cent. in gold and silver, are among the many striking evidences that if gold continues to play, and must ever play, the part of final arbiter of values, the fact of this undisputed judicial sovereignty makes daily less frequent the necessity of its direct physical intervention.

Steps yet remain to be taken to extend more widely the system of credit on the European continent and in international exchanges, to the end that the quantity of gold employed in a given volume of transactions may be decreased and its efficiency may be increased. As modern inventive genius in the field of mechanics has decreased the waste and increased the efficiency of a given unit of steam or electrical power, so it lies with the economist and practical financier to increase the effectiveness of a given weight of gold. That thoughtful men are pondering this problem is evidenced by the proposal of Signor Luzzatti, the former Italian Minister of Finance, for an international conference to consider mutual helpfulness in times of stress between the great gold-holding banks, and by the light thrown

upon the subject by such works as those of M. de Launay.

Thus, as gold has emerged from the conflict with other metals as the standard of value in advanced civilised countries, it is fitting that it should have its special literature. Many and oft have been the attempts to dethrone the yellow metal from its sovereignty and to erect in its place some inferior metal or even some pinchbeck counterfeit called a substitute or a universal money. "Coward gold" is an epithet which has been often flung by the champions of a cheaper money at the premier metal, because it has disdainfully withdrawn from those countries where the attempt was made to elevate some baser metal or a paper promise to the level of its own peerless sovereignty as a standard of value. Silver has been the subject of much writing, but it has been defensive or controversial and has been in vain. It is fitting that the triumph of gold should be commemorated by a special essay, like M. de Launay's, defining the place of gold in the world's gallery of conquerors.

CHARLES A. CONANT.

NEW YORK, July 20, 1908.

PREFACE

THE IMPORTANCE OF GOLD IN THE WORLD — THE PRESENT HIGH RATE OF ITS PRODUCTION — THE PRINCIPAL QUESTIONS RAISED BY THE ECONOMIC STUDY OF ITS OUTPUT AND ITS USES — PLAN OF THIS WORK.

At no time and by no nation, practically speaking, has gold been regarded simply as a metal, valued and desired for the practical uses to which it could be applied and the material services which it could render. These uses and these services are, of course, numerous and important, even more so than is usually supposed; but the chief and distinguishing characteristic of gold in the world is of a quite different and almost symbolic nature. Gold, while it is a commodity subject to the ordinary laws of supply and demand, is also, as we know, a representative sign, which by common consent has received a kind of international stamp. A piece of silver, or even of bronze, owing to the fact that it has been struck at the mint of a country, carries the signature of the Government by which it has been struck in the interior of that country and within the limits provided by the law; it is a draft upon the Government. But

gold has always more or less possessed the wholly special privilege and power, which has steadily continued to gain a more widespread acceptance, of being almost universally taken, without any Government guarantee, in the state of crude ingots or of gold-dust, for a certain value, which, being the typical or standard value, has the delusive appearance of never changing. There is no element of necessity in this privilege of gold; other metals and other substances might theoretically dispute it, and cases have been seen where silver, copper, iron, or even salt, corn, oxen, cloth, indiarubber and shells have been employed as instruments of exchange in preference to gold. It is possible, and even probable, that our rather primitive system of metal counters will tend in the future to lose its predominance in international relations to give place to other instruments more perfect, more easily movable, more unalterable, still more divisible and more directly founded on credit. In the meantime, however, the wholly conventional value of gold is almost universally accepted, and this invests a symbolism which is in reality barbarous with a sort of philosophic beauty. For when we find that a convention is invented and adopted alike in every nation and in every age we must conclude that its force and its necessity are of the very nature of things.

Gold is wealth and the whole of wealth. It is also the brilliant ornament *par excellence*, the untarnishable glitter of which recalls the sun; but above all it is the concrete image, the figurative reduction into

a few little discs of human fortune and all the enjoyments which fortune implies. This is the feeling of the miser when he plunges his hands into his coffers and dabbles in the yellow flood. His joy, at which we smile, makes him, in his way, an idealist and a poet, like the gambler when he takes up the cards. It is not the glint of the metal which animates and attracts miser and gambler alike; it is the vision of the fields and the woods, the houses and the furniture, the art treasures, the luxuries and the pleasures which this gold represents, which it would enable them to acquire if they wished, which at once start up and pass in procession before their mind's eye, and which are, in fact, at any given moment the potentialities contained in gold.

To insist further upon this property of gold would be platitudinous. All that can be said has been said, and well said, of the yellow metal's power to embody and concentrate in the most convenient and palpable form the product and the apparent end of human labour, the synthesis of effort, which is destined the next moment to be dispersed in the satisfaction of desires, in enjoyments and pleasures, every one of which will still be expressible in terms of more or fewer of its particles. Gold has been cursed and blessed; it has been successively, sometimes childishly, deified and abhorred. Once it has issued from the mine, from the works where it has been extracted and treated, gold runs all over the world playing with complacency, suppleness and docility the part which is expected of it, a *rôle* which

perhaps any other substance might have filled, but not so well. It passes down the centuries almost untouched by wear; the same fragment of gold cast, hammered or forged three or four thousand years ago still remains to-day what it was in the time of Pharaoh or the king of Mycenæ, in whose tombs we find it. As generations pass, a giddy flight carries it from one hand to another: it goes, sowing joy and prosperity on its way, simply because it is there, because it intervenes like a god without losing any virtue of its own. We have not here to follow it in that long series of adventures which might occupy the moralist or amuse the writer of novels; but we may be permitted, as geologists, to point out the civilizing power which it possesses, to observe how miraculous a talisman it is from the moment of its appearance in the lode or alluvium from which it is taken. Not only is it destined to irradiate human life and to transfigure it by its spell, but it seems as if its discovery in the earth transforms Nature herself and throws down the impassable barriers by which she thinks to arrest the invasion of men and to keep her solitudes for ever untrodden. No sooner has gold been found in a savage, barbarous and uncultivated country hostile to life itself, than that country is transformed. The deserts of South Africa and West Australia are supplied with water; the foggy steppes of the Arctic Ocean temper their severity; the tropical marshes and forests lose their pestilence: man takes possession of the burning and the frozen plains, of the Alpine crest, of the coast desolated by malaria or yellow

fever; he brings there, first the most indispensable necessaries, then the conveniences and, finally, the luxuries of existence. Gold may afterwards disappear from the mines, its deposits may be exhausted in a few years, but its beneficent and creative influence remains. No other means, no despotic will would have attained the same end as quickly or as surely. Thanks to gold civilization has brought its resources, its ingenuity, and its machines to the desert; there it has settled itself, constructed towns, cleared fields and traced roads, and there it remains. Long after the source of gold has been dried up and forgotten, the plain, which it once made fruitful, still prospers. Towns may suffer for a while, and populations grow thinner when the lodes disappear, but the useful work, which the discovery of gold was alone, or almost alone, capable of accomplishing with such promptitude, none the less subsists. Where modern man has planted the sole of his foot and hoisted his flag he remains. Owing to the necessity for feeding the miners, the mining centre becomes an agricultural centre; it remains agricultural after the miners have disappeared. California is richer to-day from its orchards and fields than from its ores; but it is the labour of the mines that prepared the way for the waggon.

This hunt for gold, this breathless pursuit, *Auri sacra fames, auri insana cupido*, began with the dawn of humanity; and, without insisting on this historical aspect which has been already treated too often, I shall say a few words upon the subject. But from

this point of view it is clear that we are passing through a special phase, which lends to the question of gold, at all times interesting, a special interest at this moment. On the one hand, the monetary aspect of gold, all over the world, has assumed, and continues to assume every day, a character of generality, of universality, such as it has never known before. On the other hand, the discoveries of auriferous deposits have multiplied with extreme rapidity, and the processes of extraction have become more and more ingenious and effective. The extraordinary geographical expansion, the spirit which grasps at the whole earth, in which the end of the nineteenth century equalled, if it did not surpass, the sixteenth century itself, has led to the opening-up of whole continents to our mining activities. This process still goes on day by day before our eyes with prodigious rapidity, and the regions then opened up are adopting a form of civilization which has hitherto been the privilege of a few European, Asiatic or American peoples. The means of obtaining gold are multiplying; the needs of humanity for gold show a parallel and still more rapid growth.

The triumphant invasion of the white races into vast and unknown regions has caused the discovery of colossal gold deposits, and science has found new metallurgical methods of wresting this gold from its lodes in every direction. At the same time, this penetration of the whites has everywhere introduced their means of exchange, together with their customs, needs and vices, and gold has thus been universally

demanded with an ardour, a feverish intensity, and a brutality of which men had formerly no idea. This is why the pursuit of the yellow metal has become both more passionate and more productive without perceptibly lowering its value. This is why a vigorous output, which has rapidly quadrupled in twenty years, has been prevented from rushing violently into over-production, as it would have done in the case of a less commonly used, less indispensable and less universal metal, and why a general and acute rise in prices, which is the manner in which the fall in this unique value called gold expresses itself, has been averted.

The gold output has accelerated during the last quarter of a century in vain; it is still insufficient for our needs. It is, however, far higher than it should be in view of the rare occurrence of gold in the earth's crust, if man did not throw himself upon gold ores with more passionate and exaggerated enthusiasm than, for instance, upon iron ores. The proof of this, which I shall try to give further on, has some economic importance.

The enormous development of the gold output which I have just mentioned, and which, by a singular paradox, coincides to-day with a scarcity of precious metal, should not only arouse the curiosity of those who have already had their attention drawn in other ways to the gold industry; it also seems to me to be in every respect one of the characteristic marks of our age and an influence which, owing to the economic importance of money, is most directly active, though unseen, in the life of nations. How are we to

state exactly the part taken by this extraordinary output, so utterly disproportionate to all previous experience, in the present conditions of life, in the relations between the older capital and the newer products of thrift, in the price of labour and the dearness of raw materials, in the intensity of social struggles, in the relations of countries with their creditors, in the continuous fall of interest in our present period, which is interrupted, from time to time, by unforeseen fluctuations, etc., etc.? These phenomena are all so complex, and are profoundly modified by so many others, that it is difficult to define anything clearly. Yet it is impossible that an abnormal influx of gold or, inversely, an unusual demand for it, such as is caused by the discovery of a Rand or the adoption of the gold standard in a vast, new region, should not produce, in these various connexions, more or less immediate consequences, excluding those which are directly shown in the variations in the gold reserve of the great banks, in the movements of discount, or in the changes in the relative value of silver.

We shall soon see more in detail what the recent development of the gold output has been; to get an idea, it is enough to glance at a diagram such as that on p. 108, where the curve of the gold output so proudly nears the vertical. Without going back more than sixty years (an infinitesimal period in the history of the human race), we see that in 1848 55 tons of gold were produced annually; the output rose to 202 tons between 1856 and 1860, during the great

impetus given by the almost simultaneous discoveries in California and Australia; it then fell to 145 in 1883 with the exhaustion of these same deposits, and till the opening of the Transvaal mines it remained within 10 tons of this figure. It was then, in 1889, that the curve took all at once such an astonishing upward sweep. In 1890 more than 200 tons were produced, over 350 in 1897, and over 420 in 1898; then, after a momentary and quite accidental reaction caused by the South African war, the output rose to 573 tons in 1905 and 608 in 1906. Thus in 1906 the amount of 80 million pounds sterling was exceeded (it would have been passed five years earlier but for the Boer war), and the output for 1906 is almost four times that of 1886, twenty years earlier: 84 as against 21·04 millions.

Are we at the end or only at the beginning of this tremendous movement? We shall consider this point later on; but, to forestall our conclusions, it seems very probable that for at least another ten or fifteen years the world's output will be maintained at its present figure or exceed it. If this hypothesis is well founded, shall we not some day enter upon the period of dear living which so abnormal an influx of gold should, it seems, logically bring about? Will not all prices rise to the detriment of the consumer, just at a time of social transformation which may render such a crisis still more painful? Shall we not witness more frequently than ever those social struggles in which the worker is forced to demand a rise in the price of labour in order that he may keep alive, and in which

he himself soon feels the effect of this rise, which reacts with increased force upon all the articles of bare necessity which he buys or consumes? Meanwhile, how are we to explain the fact that the demand for gold at present absorbs and even exceeds such an astonishing output?

This is enough, I think, to make us understand, if it were necessary, one of the most enthralling and most salient aspects of this study of gold which we are about to undertake. The question of gold does not only touch those who, for some reason or other, are interested in the manner of the concentration of metals in the earth or in what I call their "Metallogeny,"[1] who are concerned with their extraction, or who take part in the mining and metallurgical industries; it is equally important to any one who wishes to be well informed on economic and financial movements, which, with the development of personal property, affect all of us, from the richest to the most humble. The time is no more when one could quietly repose upon a solid family investment and when the best way to enrich one's heirs was to demand the least possible income from one's capital and to employ it in gilt-edged securities which would automatically rise in value in the course of time. To-day the management of capital has become an industry and a fine art, which requires at once attention, hard work, vigilance, and perspicacity. These qualities are necessary to avert the progressive loss of all one's capital, not to speak of making a profit! The study of

[1] The science which studies the formation of metalliferous deposits.

economic and financial questions has therefore become as useful, and, in fact, offers as much interest to the curious mind, as any other line of inquiry on which ingenuity can be exercised. The gold question dominates these problems.

Now the development of the gold output, which has just been mentioned, while it has effects and implies consequences to which our attention will especially be drawn, at the same time entails rapid modifications in the class of deposits worked and in the methods of extraction and treatment. Every one, as I remarked above, besides satisfying scientific and philosophical curiosity, derives a practical advantage from being succinctly informed as to the considerations which will soon exercise a general influence. Our study of the world's gold, therefore, besides the economic inquiry which will be the principal and crowning point of the work, will necessitate a preliminary *résumé* of the geological, mining and metallurgical problems which arise in this connexion.

Such is the aim of this book. In it readers must not expect to find information upon a number of questions concerning gold, its chemistry, its mineralogy, its use in the goldsmith's trade, etc., which have been frequently treated elsewhere. I shall insist, however, upon the industrial and geological side of problems in dealing with which economists are often too prone to rely almost exclusively on statistics, and to neglect the profound effect of these technical factors.

In the first part (Chapter I.) we shall begin logically by looking for gold where it is to be found—that is to

say, in the earth. This will lead us to a geological study of the gold deposits. Without over elaborating this branch of our subject, which could not be completely expounded without going into detail of too special a kind, we shall take care to indicate the new conclusions which result from our recent researches in metallogeny and from the new methods which we have inaugurated in that science. We shall have to consider under this head, on the one hand, the primary deposits of gold in the rocks and, on the other, its sedimentary or alluvial alterations, showing the respective importance of these wholly different classes of deposit from the point of view of production, and the changes which in this respect are brought about by time. This distribution of gold in the earth's crust, the formation of its deposits, the collocation of its ores and the modification of this at varying degrees of depth, besides being in themselves very curious, produce immediate industrial and economic consequences which we cannot pass by in silence. A most important question will then arise, the question of poor ores, the importance of which must continually increase and the reserves of which grow enormously with the lowering of the minimum workable percentage which is entailed by all metallurgical advance or any relative increase in the value of the metal due to its scarcity. We shall thus be led to state and attempt to solve the interesting problem of the mean percentage of gold which the continents and seas may contain.

After having examined the geological formation of

gold, we shall see the resulting geographical distribution (Chapter II.); we shall consider this in the past as well as the present, and try, so far as possible, to see into the future. We shall attempt to determine the proportion of gold which the various continents and countries can have contained before any gold was worked, and how much of it probably remains. By grouping statistical results with geological conclusions we shall be able to ask ourselves what countries and what mining centres are destined to furnish the output of the future, and in what degree and for how long the actual output can be expected to remain at its present figure.

We shall then pass (in Chapter III.) to mining, the recent improvements which we shall specially mention, more for the purpose of making clear the economic consequences that we may expect to result from them than of giving a complete technical description for which there would not be room, while the details can be found in the various text-books. In the same connexion we shall consider, at the end of the chapter, the metallurgical extraction of gold. Here, however, progress is so prompt and so constant, and has so immediate an effect on the output by suddenly making possible the treatment of masses of ores which never formerly required consideration, that it will be useful to dwell upon it a little further by choosing examples in the great districts like the Transvaal, Colorado, West Australia, etc., in which countries the greater part of the gold output is at present concentrated.

Lastly (Chapter IV.), the ground being thus prepared, we shall be able to approach the economic inquiry, which is the essential object of our labours. We shall see what were the uses of gold in the past and what they are to-day—the industrial uses, which are more important than is supposed (though we shall not dwell upon them with descriptive detail), and the monetary use, with which we shall have to occupy ourselves more particularly by reason of all the problems concerning money recently solved or still waiting to be solved. We shall try to get some idea of the quantity of gold possessed by the human race, and the quantity that the mines could supply in a limited time, in order to balance these figures against the demands which we shall, conversely, try to estimate. This will lead us to approach the delicate question of fluctuations in the purchasing power of gold. We shall finally examine the causes and consequences of the present development, the probabilities of its prolongation in the future, and the financial, economic or social results which may be entailed by this flood of gold which has gushed from the mines during the last fifteen or twenty years at the rate of eighty millions a year.

TRANSLATOR'S PREFACE

In presenting my version of M. de Launay's book I think it advisable to make one or two explanatory remarks, especially with regard to the quotation of figures, to avoid any possibility of misapprehension by English readers. In all cases I have taken the figures given by M. de Launay and converted them as nearly as possible into their English equivalents. For the sake of clearness, I have quoted all large sums of money in millions of pounds to two places of decimals, thus ignoring (in statistical tables only) sums under £10,000. I hope by this means to have guarded against the bewilderment which is likely to be caused by long rows of noughts. In the case of small weights, where accuracy was necessary, I have given the equivalents to two places of decimals; in other cases, where the figure was only an approximation, I have given the nearest whole number. Finally, for large weights I have thought it most convenient to use the metric ton (1,000 kilogrammes) as the unit, in order to avoid decimals. A metric ton is roughly equal to 2,670 lbs. troy and 2,200 lbs. avoirdupois. Strict accuracy cannot therefore be claimed for the statistics, since conversion always leads to inaccuracy,

in spite of the greatest care. It must also be remembered that a great part of the figures given by M. de Launay have been previously converted by him into their metric equivalents, and that in most cases he only gives them as approximations. Further, I found in verifying the totals given in the statistical tables that they seldom corresponded accurately to the sum of the items. I consulted the author on this point, and he replied that the difference came from the inclusion of amounts from other sources too inconsiderable to be mentioned in detail. The separate items and the totals may therefore be taken as tolerably, but independently, correct. Where this is the case, attention has been called to the fact in a footnote.

O. CYPRIAN WILLIAMS.

11, Porchester Place, W.,
June 3rd, 1908.

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THE WORLD'S GOLD

CHAPTER I.

THE GEOLOGY OF GOLD.

Introduction—The conventional character of the definition of gold ore—The distinction between ore and barren rock purely industrial—A decrease in mean percentage follows technical progress—The growing importance of poor ores.

§ 1.—The early origin of gold — The causes of its rarity — The three chief classes of deposits: inclusions, veins and sedimentary deposits — Their relative importance.

§ 2.—The primary deposits of gold—The relations of gold with igneous rocks and its departure under varying conditions according to the level in the earth's surface reached by the rocks in ignition—Its association with other minerals—Conclusions to be drawn as to the origin of gold—General remarks: A. Gold in relation to granitic rocks—B. Gold in relation to volcanic rocks — C. Pyritous deposits of gold—D. Auriferous pyritous conglomerates—E. Tellurides of gold.

§ 3.—Deposits of secondary concentration—Chemically altered ores—Veins of native gold—Red earths and laterites.

§ 4.—Deposits of secondary concentration (*continued*)—Mechanically prepared ores—Auriferous alluvia—Placers.

§ 5.—The percentage of gold in the continental masses and seas—Future reserves of gold—Extreme localization of the large deposits.

Introduction.

When the general public or any one outside the ranks of the specialists thinks of a deposit of gold they nearly always imagine it in the form of an alluvium, with prospectors washing the sands of watercourses and with glittering nuggets. There is something romantic about the picture. The better informed have, besides, the conception of a vein, the vein of theory —a great wall of ore striking vertically into the earth

—which they readily imagine to be formed of practically solid gold. Indeed, the younger Dumas, in one of his plays, was able to put a celebrated speech into the mouth of an explorer who was supposed to walk about the mountains in search of veins, which he recognized by their ring under his hob-nailed boots, without in any way astonishing a distinguished audience. This is an error of ignorance which the recent spread of financial interest in the mines of the Transvaal has perhaps helped a little to rectify. Yet it is none the less necessary to combat it at the start. In fact, it implies a complete misconception as to what are gold mines and gold ores, and, above all, ignorance of that continuous bond which links together rocks called ores and rocks called barren, which are only separated by a wholly empirical and perpetually changing border line.

The first point which must be clearly and distinctly fixed in the mind is that alluvia tend to play a more and more restricted part in the production of gold, a part destined, in all probability, to vanish entirely about a century hence.[1] The second point is that the large outputs of gold, the only ones which really count, are generally yielded by very poor ores. The poverty of these ores seems to increase with time, but this is not due so much to exhaustion as to the new possibilities for economically treating rocks, when technical progress has caused their value to exceed the cost of extraction.

Whatever the metal in question, an *ore* is solely

[1] See on this point the table on p. 18.

characterized by the fact that it is "paying." If it does not pay, it is no more than a common stone in which analysis has found traces of metal. This alone constitutes the practical difference between ore and *barren* rock. What was barren yesterday will be ore to-morrow if metallurgy is perfected; if, on the other hand, the price of the metal falls, what was ore yesterday to-morrow may be considered barren. So far as gold is concerned, the price of which is by convention and definition constant, the former alone has up to now been the case, and, with momentary exceptions, will no doubt continue to be so on the whole, since a permanent over-production of gold seems improbable, for a very long time at least, in view of the intensity of the industrial and financial demand; and since traces of gold are widely spread over entire mountains of rock, while the sea itself with its immense extent contains particles which chemical analysis is able to reveal, if only the demand for gold were to increase sufficiently and men were disposed to pay dearly enough for it, quantities which, if not unlimited, would at least be far superior to any contemplated in the most optimistic calculations, could be extracted from these sources.

It is necessary to gain a clear idea of this essential point at the start and to that end to consider the difference between the case of a metal which, since the consolidation of the earth's crust, has formed an integral part of that crust—except that it has concentrated more or less at particular points—and that of a substance accidentally introduced by organic action

into a few definitely marked formations, like coal, the deposits of which, being better known, have contributed to create the false idea which I am trying to dispel. A combustible is altogether distinct from the mineral matter which surrounds it, while gold, or any other metal, in its primary deposits (not altered as the alluvia) forms part of such matter. No doubt a rise in price would equally render a number of beds of coal workable which are now neglected as being too thin, too earthy or too deeply situated, and if the human race were absolutely in need of coal and if no means of doing without it could be devised, reserves would be discovered far larger than those given by ordinary calculations based on the number of beds of coal at present workable. Nevertheless, coal does not exist outside the sedimentary strata formed in past ages on the surface of the earth by a deposit in the waters of lakes, estuaries or seas, strata very restricted in superficial extent and with a limit of depth which is soon reached. Of these sedimentary deposits themselves only a very small group contains carbonized vegetable remains, even in the smallest quantities, and in these formations of carbonaceous beds a natural mechanical preparation, similar to that which we perform in the laboratories, has already separated the coal from the sands or clays, which have become sandstone or schists, so that on this head we cannot add much to the work of Nature. Except for certain intermediate stages where the industrial process of picking is introduced, a bed is necessarily and incontestably either coal or barren;

the line of demarcation is neither arbitrary, empirical nor temporary—it is absolute.

On the other hand, without going so far as to say of gold, as a certain famous barrister said of arsenic, and as could be said more truly of iron, that we find it everywhere if we look well for it, it is certain that the cubic content of the rocks in which a sufficiently delicate chemical analysis would reveal the presence of gold is immense. I shall attempt further on to illustrate this by giving figures to show the mean percentage of gold in continents and seas. Further, it is essential to remember that this holds good not only on the surface of the earth, but at all depths. If there is a theoretical modification of the proportion of gold which the earth's crust can contain at varying distances from the surface, all the probabilities are on the side of an increase when we get near enough to the centre. To obtain more gold it is only necessary to put a price on it, to crush poor ores sufficiently fine to treat them long enough and a sufficient number of times with solutions of cyanide and chlorine and, finally, to go deeper down into the lodes. A stock of unused ores is already waiting on our mines: these form the "rubbish" which has been rejected as barren—the masses which have been neglected on all the workings as unproductive.

Gold is very dear. It costs 3444*fr.* 44*c.* the kilogramme (£137·77 for 2·67 lb.) and 3*fr.* 44*c.* a gramme (2*s.* 8½*d.* for 15·43 grains troy). It is far from being the dearest of the metals, for platinum, not to speak of the rare earths, easily exceeds it in price;

nevertheless it is dear enough for the minimum productivity at which a gold ore ceases to be paying, and consequently workable, to be very small. Contrary to current notions, it is the poor ores near the minimum limit which furnish the great outputs and also yield the large profits. It must not be supposed that the brilliant industrial results are obtained with ores of great productivity which insure a high profit all at once; this is a delusion far too common among dabblers in gold mines. The very rich ores are very rare, and are becoming more and more rare as time goes on for all kinds of reasons, the chief of which are that these rich ores have had more chance of attracting attention and therefore of being already removed, a least from the surface, and also that a by no means arbitrary geological law, the causes of which we shall attempt to analyse, does not permit their abundance. This law is that gold, a dense metal poor in chemical affinities, must necessarily be rare in virtue of these very properties; exceptional concentrations of it, of which some cases have been found, are, and always will be, a very abnormal phenomenon. The distribution of gold in the earth is like tax-returns; in spite of false ideas, it is mass and number, not the exception, to which attention is violently attracted, which give the real results and the large figures. It seems evident at first sight that the abundance of poor ores exceeds that of the rich ores; but this abundance increases with the decrease in productivity much more rapidly than one imagines.

To confine ourselves to the present conditions of

the industry, the treatment of a gold ore in certain cases costs a few half-pence the cubic yard, more commonly a few shillings, and in the most difficult cases 24*s.* (£3 to £4 a ton). This corresponds to a percentage of gold represented by a good many noughts after the decimal point, from a decigramme (1·54 grains) to a cubic metre, or $\frac{1}{30,000,000}$th of the weight, to 30 grammes (462·96 grains) to a ton, or $\frac{1}{33,000}$th of the weight. It is unnecessary to remark that in such ores the gold is almost invariably invisible. The ores with visible gold, such as can be seen in mineralogical collections or sometimes displayed in the windows of agents to attract shareholders, are only monstrosities, and, as a rule, also indicate an irregularity of distribution which is unfavourable to a stable industry.

This growing importance of poor ores, on which I shall have more than one occasion to insist, lends a special interest to the primary formations which I shall define under the names of inclusions and veins —formations in which gold, having neither been concentrated by chemical means, as in the altered surface deposits, nor by mechanical means, as in the alluvia, is found in small quantities. These ores, which historically have been the last to be discovered and worked, and which still play a very secondary part in industry, are destined to take an increasingly large share in the future output, as the other categories, being more accessible and easy to treat, become exhausted. We are, therefore, in every way forced to examine this class of deposits with

particular care; for the study of them, as we shall see, is of a nature to enlighten us as to the genesis and origin at some depth of the gold which is found in our various mining works.

§ 1.—*The primary origin of gold—The causes of its rarity—The three great classes of gold deposits: inclusions, veins and sedimentary deposits — Their relative importance.*

THE RARITY OF GOLD: ITS GEOLOGICAL CAUSES.—The gold which our labours have hitherto been able to extract from the earth, whatever be the depth (to our seeming very great) of our mines, is, in reality, always gold taken from the regions at the very surface of the globe and localized in that very thin outer coat of the earth's crust (hardly 1¼ miles deep to a radius of 4,000) which we are about to explore. We only look for it in the places where it is found concentrated in *abnormal* quantities—this preliminary condition being one which governs the choice of all the deposits attacked in our mining operations, whatever be in the end their absolute productivity. By an optical illusion, which repeats itself in every kind of human research and knowledge, we take as typical those conditions with which habit has made us familiar, and regard as extremely rich those deposits in which the percentage of gold is in marked excess over the average on which the price of the metal has been fixed for common uses. This percentage, in the case of gold, is very small. When we try to estimate it, we shall arrive at the conclusion that the surface

crust, in which there is about 4·70 per cent. of iron, can be approximately calculated to contain from ·0000025 to ·00000025 per cent. of gold, or from 1 in 40 millions to 1 in 400 millions.

The first question which presents itself to us is whether this poverty of the earth's crust in gold corresponds to a general rarity of gold in the whole fabric of the terrestrial globe, or whether it means that the gold contained in the earth is chiefly localized nearer to the centre, in regions to which we have no access. At the same time, we are led to look for the origin of gold, the causes which have fixed its localization in this or that part of the earth, and the phenomena which have caused its accidental departure to the regions nearer the circumference and favoured its more abundant crystallization in certain parts from which we extract it. It can be seen at once that the problem has a theoretical interest, for the hypothesis to which we are brought as to the early origin of gold and the process of its departure or of its concentration at the surface will lead us to the general classification and explanation of its deposits. The problem has also a practical interest in giving us an idea of the variations to be looked for in the mean percentage of gold when we penetrate exceptionally deep into the earth and approach regions really profound and, in all probability, more abundantly metallized, the riches of which we shall one day come to utilize.

The general considerations, then, by which I think it necessary to begin relate to a whole theory of

metallogeny which I have expounded elsewhere[1]; I shall be content here to restate my conclusions. It is necessary to have these ideas present all together in the mind, if we wish to understand the geological notions more specially relative to gold which follow. In the theory which I here summarize, we are led by a whole series of conclusions founded upon a synthesis of metallurgical observations to demonstrate, or, rather, logically to infer, that during the incandescence of the earth, before its solidification, a general classification of the chemical elements took place in order of density. The atoms must have found themselves separated from the centre in inverse proportion to their atomic weight, the lighter atoms taking their position in the region of the circumference, as if universal attraction and centrifugal force had been the only forces at work, independently of all chemical affinity, and the dense metals, on the other hand, gathering towards the centre. Subsequently a whole series of displacements, which modified this primary arrangement and determined exactly those abnormal concentrations where we go to search for and work the metals, were caused by the contractions of the earth's crust, by fusion, volatilization and internal circulation of volcanic fumaroles and subterranean streams.

Under another form, which I believe to be inexact, a law of the same kind had been already perceived by other geologists, but they had directly applied the idea of a primary classification to the weight of the

[1] L. de Launay, *La science géologique*, p. 627 *seq.*

substances which the earth's crust contains to-day, on the hypothesis, which was supported by a few rough observations, that the rarer the metal the greater is its density, its concentration having taken place at a greater depth. This implies the supposition, in the first place, that the present solid crust has remained identical with the original fluid region the place of which it occupies, and secondly, that all the metals began by existing in equal quantities in the molten globe, their greater or less density being solely due to their classification. This idea was specially applied to gold, and a sufficient explanation of its rarity at the surface, which has been mentioned many times, was found in its density, gold with a density of 19·253 being rarer than silver (10·474) and lead (11·352), not to mention iron, calcium, etc., metals with still lower densities. But, presented in this way, the law raised very numerous and very obvious objections. A palpable one is the relation of lead and silver in respect of density. Lead, if the law were exactly as it was formerly stated, should be rarer than silver. We know how different the actual case is. In fact, it is impossible to consider the density of a metal as alone implying a greater or less rarity at the surface. The initial quantity of the various metals is totally unknown to us and may depend on wholly accidental causes; moreover, the phenomena to which the localization of these metals in the crust is due are more complex and depend at least as much on the chemical affinities by which the metals were drawn towards certain volatile metalloids, such as chlorine

or sulphur, and thus carried off in the form of fumaroles, as on their atomic weight. If the old law of density determining by itself the rarity is often (especially in the case of gold) approximately verified, the reason is that by a phenomenon of which chemists still owe us the explanation, the chemical affinities of a metal are, as a rule, in inverse ratio to its density.

THE GENERAL CLASSIFICATION OF GOLD DEPOSITS.—The following is a summary, to the details of which I shall return later, of the account which I think ought to be given and of the manner in which the different classes of gold deposits seem to me to be connected by a bond of common origin.

We must imagine first of all, as we saw, an initial classification in order of density, carrying the heavy metals to the centre and the lighter elements to the circumference, while the globe was in a molten state. This classification must have been very irregular and disturbed, because the molten globe was necessarily the scene of eddying movements, due to thermic or electric currents, of which the study of the sun allows us to form an idea. The deep-seated elements might therefore have been carried to the surface at certain spots and in a quite accidental manner. But, on the average, it is obvious that the denser they were, the harder they found it to reach the surface, although this difficulty might be compensated (an important limitation) by a greater affinity for other elements able to lend them mobility. These last-mentioned elements are those to which the name of mineralizing agents

has been given, and their influence has continued in the same direction throughout the history of the petrographic magma and of metallogenic consolidations. A time then came when the upper crust of the igneous mass solidified in scoria and when the outer envelope of steam and various gases was thus separated from the inner parts. The earth from this moment was divided into three principal regions, the interaction of which constitutes the whole of geology: (1) the atmosphere and the seas; (2) the solid crust; and (3) the igneous and incandescent magma, which could exist at great depths and exercise an action towards the surface, either by the discharge of localized heat following the lines of certain vents or by an emanation of fumaroles.

It was in the subsequent periods that geological phenomena properly so called were produced. Either the earth's crust was crumpled or dislocated under the stress of internal forces, from which come the mountain ranges, volcanic phenomena, crystallizations of *eruptive rocks*, not only in the form of protuberances on the surface, but also of intrusions and deeper penetrations of the granitic type, which the destructive action of erosions has made to appear later on the surface, or, in other periods of time, the projections thus formed have been destroyed by the trickling of water, and their detritus, carried in the torrents and drawn towards the lake or sea basins, have formed there that class of deposits which is called *sedimentary*, and more particularly, when it is a question of fairly recent alteration by a watercourse, *alluvial*.

In this series of movements, fusions, classifications and reactions which have constituted the metallurgy of Nature, the metals, borrowed from regions of greater or less depth which were thus called on momentarily and locally to take their part, came into play and assembled at certain particular points. In this complicated series of phenomena these metals answered to the play of the various natural forces already mentioned in proportion to the greater or less aptitude that they could show for rising to the surface where we find them and for consolidating there in this or that workable deposit.

There were first of all direct crystallizations of metals in the mass of molten rock, which consolidated under all the forms studied by petrography. These crystallizations, accompanied by a possible *eliquation*, *segregation*, or *differentiation*, that is to say, by a separation and local concentration of the elements, and favoured by the mineralizing agents, gave the first class of metalliferous deposits, the most directly in relation with their original point of departure. They are therefore the first to be studied, but also, as a rule, the consolidation of them is least complete. We shall call these deposits *inclusions* and *segregations*.

After these come the *hydrothermal deposits*, veins or lodes. These are fissures of any form or origin in which metals have crystallized after rising in solution in hot water, which had begun to become metallized by contact with vapours or fumaroles emanating from the above-mentioned rocky magma. These lodes,

which represent a second stage in the natural metallurgy, by which Nature has constantly laboured to replace the scattered elements in their proper order and to present them to us in a more accessible form, are generally richer than the inclusions, and form a class of deposits more profitably and more frequently worked.

Finally, these lodes or inclusions themselves may have been subject to alterations on the surface, effected, in the case of rocks and lodes, by their contact with the surface waters, which are always charged with chemical agents, the most abundant and most active being carbonic acid and oxygen. The result has been either a transformation *in situ* by chemical means, which gives place to what is called an *altered deposit*, or a displacement by dissolution; or, again, the erosive action of surface water on outcrops already altered has sometimes caused a mechanical change, from which come *sedimentary deposits* and *alluvia*.

These considerations, which we shall now apply to gold, do not relate exclusively to that metal, but I did not think them sufficiently widely known to dispense with this little lecture on the origin of metals.

THE RELATIVE PROPORTION OF THE DIFFERENT CLASSES OF GOLD DEPOSITS.—In the special case of gold all the classes enumerated above are represented in practice, and assume an industrial importance, though this does not hold of other more common and less valuable metals, of which only

the highly concentrated and very rich deposits—sedimentary deposits or superficial alterations of veins—have any value. But, even in the case of gold, these richer types began by yielding particularly productive ores, easy to work or treat metallurgically, and it was these that were attacked in the most ancient workings. The historical order of mining works, therefore, both taking the history as a whole and in the particular case of a definite district, is generally the reverse of that which we have just followed in tracing logically the stages by which the metals have passed through geological changes. As a rule, the most recent alluvia have been the first to be discovered, in which the work of mechanical preparation had been pushed furthest and had succeeded to an enrichment by alteration, also highly developed. It is in these alluvia that, in the beginning, the nuggets of native gold and gold dust were found which symbolize, as I said on the first page, the idea of a gold mine to the majority of people. Next, on the exhaustion of these alluvia the primary deposits in lodes or rocks were looked for, but still only to attack the upper part at first, the outcrop which oxidizing action, set up by the flow of water, has usually made richer in free or easily amalgamable gold. There, too, easy conditions have prevailed, but they disappear when we plunge more decidedly into the depths. This is very soon made necessary in any particular mining centre by the advance of the working, and in the case of the earth generally by the continual progress in the exploration of the surface.

The easy period of gold workings, when the gold comes from alluvia, is altogether momentary, and, according to an often quoted remark of De Humboldt's, the reason of which is not far to seek, only occurs in the regions on the outskirts of civilization, in the advanced "marches" which serve it as frontiers. This class of deposit tends to disappear as man's hold on the earth advances, and new discoveries, however sensational they may be, are not sufficient to compensate for the exhaustion of older districts. In any place where man has dwelt for any length of time, he can no longer expect to discover alluvial deposits, the presence of gold in them being too easily detected and, in virtue of the yellow metal's prestige, too quickly recognized by the least expert, while the working of these ores is limited to a short and too rudimentary operation, which is within the range of all. Properly speaking, auriferous alluvia only remain to-day in parts very adversely treated by Nature, under the ice, snow, or marshy turf of the northern regions, in the pestilential forests of the tropics, the deserts, and a few high valleys in mountain chains. Besides, the alluvia which still exist, the majority of which have long been known, although from time to time they are rediscovered with a beating of drums, are either so poor that it would be impossible to cover the cost of extraction, as in the Po valley and the plain of Granada, or covered by more recent strata and lava flows which turn them into really deep beds, or, finally, situated in a country, like California, where the law forbids the employment of the only methods capable

of giving a profitable yield, in order to protect another source of wealth, namely agriculture.

The following table, the first columns of which are borrowed from Mr. Suess and the last of which I have tried to calculate myself from the still incomplete data which we have for 1905, is very striking from this point of view, the more so as only the short period of sixty years in the history of the human race is in question :—

	1848–75.	1876.	1890.	1905.
Alluvia	87·28 per 100	65·28	44·20	15
Lodes	12 02 ,, ,,	34·76	47·80	57·50
Sedimentary deposits (Transvaal conglomerates) ...	—	—	8·00	27·50

At present the importance of alluvia is restricted to a very small number of regions, of which the chief are—first, Siberia, where they soon become exhausted, as the continuous decrease in the Russian output is sufficient to show; then the arctic districts of Cape Nome and the Yukon in North-west America, New Zealand, the Guianas, Rhodesia, and some secondary centres like Madagascar. Certain sedimentary deposits in the form of conglomerates (the real origin of which may be from veins, and which, in any case, take the shape of veins so far as working is concerned) have at the moment assumed considerable importance in the Transvaal and in the very scanty remains of the West African gold fields. Everywhere else, notably in the United States proper, only lodes are worked, the hydraulic operations in California having

been interrupted, and we are seeing the moment quickly arrive when this will be so all over the world.

§ 2.—*The primary deposits of gold—Its relations with igneous rocks and its departure under varying conditions, according to the level in the earth's crust reached by the rocks in ignition—Its association with other minerals—Conclusions to be drawn as to the origin of gold—General observations—Pyritous deposits of gold—Auriferous pyritous conglomerates—Tellurides of gold.*

As I have just repeated in brief, in our theory of metallogeny, gold, like all other metals, was first consolidated in what we call the *primary deposits* (inclusions or veins) by igneous metallic action upon eruptive magma with the help of metallized fumaroles[1] and hot water. It is these primary deposits which were subsequently altered and changed chemically or mechanically to form deposits called *secondary*—alterations *in situ*, sedimentary and alluvial deposits. It is necessary, therefore, before going further, to examine the relation of the metal with these igneous rocks, the part played by the fumaroles, and the mineral associations that result. It will be difficult to do this without using several technical terms, which may render the reading of this section rather arduous to non-specialists. However, I cannot pass these matters over in silence, for they have both theoretic interest (chiefly for the chemistry of

[1] *Fumaroles.* Vapours generally chlorinated, sulphuretted, or carburetted, which rise from volcanic rocks with an excess of steam.

minerals) and a certain practical value, and we shall have to return to them in the sequel.

The general ideas which I shall attempt to expound on this occasion as to the metallogeny of gold are partly new.[1] Indeed, few studies have been more completely revolutionized in half a century, and this is due not only to natural advance in geological knowledge, but still more, perhaps, to the fact that every discovery of a new great gold-bearing district has disturbed the ideas held up to that time by bringing in an uncommon type which it was necessary to fit violently and by main force into theories formerly held. Though this is quite a normal development in industry, since the already known forms of a substance, having already been explored and worked, with difficulty lend themselves to sensational discoveries, the fact has never received such striking illustration from the other metals, such as lead, zinc, copper, etc., in regard to which we have been able to fall peaceably asleep upon a "chair already made." On the other hand, let us glance at what has happened in the case of gold. Before 1847 it could be maintained that all gold came from ancient strata. This was the time when gold came from Siberia and some deposits in Europe. Then the deposits of California were found in 1828 in Tertiary lodes. The gold of Eastern Australia, worked since 1850, is also in lodes. For a long time nothing but large lodes of auriferous quartz and clean fractures of veins

[1] The principal points in this account appeared for the first time in the *Revue Générale des Sciences* for 30th June, 1906.

was seen. But in 1887 the Witwatersrand was discovered, and here the gold was in a cement of Primary conglomerate. Prospectors then used to traverse not only South Africa, but also other continents, in search of conglomerates. Now it is tellurides which at Cripple Creek (in Colorado) and Kalgoorlie (in West Australia) feed the two chief gold fields of the earth. These successive changes in the nature of the great gold deposits, to which attention is most strongly drawn, are calculated to inspire us with much reserve in propounding theories, and it must be confessed that even to-day, after all the progress of late years, our knowledge of the metallogeny of gold is not completely established. A certain number of principal points, however, seem to be fixed by this time, and it is these which I shall now pass in review.

THE ASSOCIATION OF GOLD WITH IGNEOUS ROCKS—GENERAL OBSERVATIONS.—The original association of gold with eruptive rock crystallized at a greater or less depth is, as will have been noticed, the fundamental principle of our whole theory of the arrival of gold in certain selected places where we find it in our mines, because this internal phenomenon carried and deposited it there at a distance from the surface which might have been very great at the moment when the deposit was made, but which the prolonged action of erosions has reduced to nothing by destroying the outer crust of superimposed strata.

This consideration of the original depth at which

the rocks were formed and the metals deposited is still too little recognized to make insistence on it unnecessary. In fact, we must never forget, when we examine any point on the surface of the earth to-day, that this point where we now find a rocky or metalliferous outcrop may, in the far-off age when this rock or this ore consolidated there, have been a mile or two below the surface, at a depth often much greater than those of our mining works. Thus it is perfectly well known that granite always crystallized at a great depth under the conditions of homogeneity and pressure which this depth implicated; other rocks, which we call the microgranulites or porphyries, rose further towards the surface; others, again, came right to the light of day and protrude in the manner of volcanic flows. But the more ancient the formation of the terrestrial masses which we consider, the more rare the last kind—the superficial flows of lava—is found to be, the flows of that period having been more exposed to disappearance through erosion, which has acted far longer on them than on the more recent flows. Thus the observations which we make at the surface or in our little mine-shafts, so shallow in reality, lead us to touch and examine formations the primary depth of which may have been one, three, six, or even twelve miles below the surface, according to the geographical position and the time to which the consolidation of the rocks in question under their present type goes back.

In passing in review the different associations of gold with different eruptive rocks we must saturate

ourselves with this idea; we must, so to speak, follow in spirit the ascension of the igneous magma and its crystallization under petrographic forms, varying at different depths and accompanied by discharges of fumaroles and vapour "puffs" which brought the gold up with them, subjecting it to the action of overheated subterranean streams under conditions which we shall come to analyse. Our end is, first, to state clearly the essential idea of all these theories concerning ores, which is their original relation with the more or less deep-seated eruptive rocks from which they are derived, in order to demonstrate it by illustration in the special case of gold, and, in the second place, to arrive at this relation so far as gold in particular is concerned.

The ways in which gold has crystallized in a primary deposit (inclusion, segregation, or lode) in more or less direct relation with an eruptive rock reduce themselves to five principal types, which we shall enumerate successively, starting from the rocks of deep-seated crystallization and going to the rocks crystallizing nearer the surface. Some of these five principal types can in their turn be subdivided.

(1) *Relation with rocks of granitic structure—The stanniferous and cupriferous groups.*—Very often gold has parted at some depth from magma of granitic structure under conditions which bring it near the stanniferous group (tin, bismuth, tungsten, etc.).

(*a*) It may then exist in such rocks in inclusions, either in granites, especially the granites of white mica, or (perhaps when the granitic magma has

absorbed and assimilated calcareous sediments) in greenstone, diorites, etc.

(*b*) Again, it may have isolated itself from this granite in a state of veins similar to those of tin, that is to say, which belong to the groups of white mica granites and pegmatites or which are simply quartzose by elimination of all elements but silica. Chalcopyrite is often found in these, and also arsenic in the form of mispickel.[1]

(*c*) Finally, it seems that a series of deposits very important in gold mining must be attached to this group, which—in the crystalline strata which have taken the form of gneiss, mica schists, amphibolic schists, etc., through deep-seated metamorphic reaction[2]—form impregnations, lenticles, fahlbands,[3] etc., mineralized with pyrite, mispickel, or auriferous chalcopyrite.

In this case, as a rule, the association with granite is not explicitly shown; but the deep-seated reaction which has introduced the gold into the very fibres of the metamorphic cement is clearly marked, and it appears that this reaction should be attributed to intervention of igneous magma, of which granite is one of the characteristic forms and of which the other more basic forms may rather be attributed to endomorphoses[4] of fused enclosing rocks than to

[1] *Chalcopyrite.* Sulphide of copper and iron. *Mispickel.* Sulpharsenide of iron.

[2] *Metamorphism.* Transformation of a stratum or rock by reactions subsequent to their formation.

[3] *Fahlband.* A term employed by German miners to designate schistose regions mineralized with sulphur.

[4] *Endomorphosis.* Action exerted on an eruptive rock by the enclosing strata the parts of which it absorbs.

differentiation[1] properly so called. These auriferous impregnations in metamorphic strata are extremely common in Siberia (the Lena and Zeya), Guiana, Brazil, Central Africa, etc. It must be noted that in this group gold follows the same path as copper, with which it could already have associated in the lodes of the stanniferous type (*b*), but which is here clearly separated from tin. It is usually associated with sulphur and selenium (pyrites of iron, etc.), but arsenic is also a common element (mispickel, etc.).

(2) *Relation with porphyroid rocks—The antimony group.*—More superficial intrusions of igneous magma in the form of porphyroid granulites[2] or microgranulites[3] may be accompanied by gold. This is a type of deposit often characterized by the presence of antimony, a metal very similar to tin in its crystallization into the heterogeneous quartzose veins of the pegmatoid group frequently associated with such classes of rocks in the form of dykes[4] or intrusive sheets, but which nevertheless seems to have gone further away from the mother rocks, as it is more easily maintained in solution. We shall have to mention many cases of auriferous stibnites.[5]

[1] *Differentiation.* The chemical process of separation and eliquation in the elements of a molten mass.

[2] *Granulite.* White mica granite appearing to be formed by reaction in which hot water charged with alkaline carbonates and chlorinated fumaroles has had more influence than in the case of granite proper.

[3] *Microgranulites.* Igneous rocks of porphyric aspect when examined with the naked eye, which microscopic examination shows to be similar to granulites, and which, as a rule, appear to have crystallized nearer to the surface than granulites, although remaining in subterranean intrusions.

[4] *Dyke.* Vein of eruptive rock.

[5] P. 34.

(3) *The plumbo-argentiferous group.*—There is no doubt that under a similar group, with a more advanced "departure" and a further separation from the mother rock which brought the gold from the depths, we must class the whole series of complex veins of the plumbo-argentiferous group, in which gold plays a considerable part, especially, it appears, when silver has developed at the same time. Besides the presence of sulphur, which is practically constant in all auriferous ores, the appearance of gold in this class of deposits seems sometimes to be associated with the presence either of arsenic or fluorine, which, as we shall presently see, assumes a more important character in the deposits which follow.

(4) *Relation with recent eruptive rocks—Auro-argentiferous lodes.*—The auro-argentiferous lodes proper constitute a well-known group, very productive and important in mining. Most of them, if not all, seem to be already in relation with the upper and almost superficial parts of eruptive phenomena, and consequently show a preference for the Tertiary rocks, since these have been, by their nature, less deeply worn down than the older rocks, having been subjected to a less long erosion, and show their highest parts above the surface. These lodes, which may pass either into the preceding or the following type and which often mix with complex and telluretted lodes, appear very frequently in the volcanic zone of the Pacific Ocean, in numerous points of Western America or Mexico, in Transylvania, etc. Many of them (in Colorado, Nevada, etc.) are in close relation

with neo-volcanic *foci*, that is to say, with relatively high portions of eruptive intrusions.

The very great richness in precious metals of the whole of Western America, from Alaska to Tierra del Fuego, is perhaps simply due to the ordinary age of the plications which the strata of this district have undergone. These plications, begun during the Secondary and continued during the Tertiary period, are old enough for erosion to have exposed a metallized stratum which in the more recent Alps and Pyrenees has not yet reached the daylight, and are yet not old enough for this metallized zone, the vertical depth of which we believe to be limited to and localized in the crust, to be entirely destroyed, as has happened elsewhere in the more ancient masses.

(5) *Relation with volcanic rocks—Assimilation to the mercury group.*—The auriferous fumaroles, finally, may have been able to escape right up to the neighbourhood of the surface, in direct connexion with intrusive eruptive phenomena of volcanic character, for we meet gold in the form of very numerous and irregular veins, sometimes bizarre in shape, in a certain number of volcanic centres, which seem to have been hardly touched by erosion and in which we find, if not the craters themselves, at least the chimneys with the eruptive sheets and bosses—conditions which recall those of mercurial deposits. Gold is in this case associated with active mineralizing agents, of which fluorine is the principal. Fluorite[1] is a characteristic gangue of lodes of this kind, which often present gold

[1] *Fluorite.* Fluoride of calcium.

in combination with tellurium in the form of tellurides of gold and silver, into which, by an affinity which I have just pointed out, mercury may enter as a constituent element. This is the case in some great and very rich centres of gold production, such as Cripple Creek in Colorado, Kalgoorlie in Australia, Transylvania, etc.

Thus we have seen, according as we considered igneous magma nearer and nearer the surface, gold enter by a progressive evolution into the different groups characterized by this or that metal the predominance of which corresponds in general to a more and more superficial formation of the rocks, a crystallization that is, under a less and less pronounced pressure, first in the group of tin (1 *a*, *b*), then in that of copper (1 *b*, *c*) or in that of antimony (2), in that of argentiferous lead or B.P.G.[1] (3, 4), and even in that of mercury (5).

In conformity with the types of rock, granites, porphyries, and trachytes, associated with more and more distant periods of consolidation, the types of deposit themselves are modified with the progress of this ascent to the surface from the segregated pipes or deep-seated contact veins through the great plumbo-argentiferous or auro-argentiferous fissure veins to the networks of little veins scattered about almost on the surface with fluorite and tellurides.

It seems therefore that, in the special cases where the original molten mass contained gold at a depth,

[1] *B.P.G.* An abbreviation for blende, pyrite, and galena, sulphides of zinc, iron, and lead, which are constantly associated.

this gold has been able to separate at various levels of the internal ascent in combination or association with very different mineralizing agents, which, as we shall see, comprise nearly all the series of metalloids, with chlorofluorides, sulphur, tellurium, arsenic, and antimony, probably predominating. Elsewhere, and much more generally, rocks wholly identical with those from which gold deposits seem to be derived contain no trace of gold. We must therefore seek (as we must in more or less marked degrees in the case of all other metals, according to their rarity) for the influence of an original phenomenon, at a relatively considerable depth, which at this or that point of the globe had already concentrated gold in the original igneous magma, and it seems to me that the origin of this primary gold, by reason of its density, must be looked for in those internal strata of our planet which have only had rare, accidental, and ephemeral communication with the surface through some vapour-puffs or fumaroles.

THE MINERALOGICAL ASSOCIATIONS OF GOLD—THE INFLUENCE OF MINERALIZING AGENTS.—Let us now see what are the associations of gold in these various types of deposit, which will help us to understand the characteristics of this natural metallurgy. These associations, as I have just shown incidentally, vary according to the nature of the deposits in which gold is worked. The most constant are those which have affinity for gold: quartz (its almost constant gangue), iron pyrite, and, we must add, silver, to which we

pay less attention, but which generally occupies an important place in the impurities of native gold.

We must, in fact, remember that native gold and gold obtained by various metallurgical processes is always impure before refining and differs from fine gold by the presence of other metals, chiefly silver, then copper and iron. The proportion of silver in an electrum may reach 36 to 38 per cent. Usually the percentage of fine gold in native gold varies from 85 to 95; very rarely it reaches 98 and 99. Almost the whole of the residue is made of silver, with a proportion of copper which never exceeds 40 per cent., of iron which in exceptional cases reaches 3·75 per cent., and in some very rare cases a little platinum.[1] In California gold dust is only $\frac{850}{1000}$ to $\frac{870}{1000}$ fine, and the largest pieces $\frac{950}{1000}$. At Klondyke the proportion is particularly poor, being $\frac{850}{1000}$ on an average and often hardly $\frac{700}{1000}$. Practically all the deposits of gold, then, show this association of gold and silver, which has been noticed especially in the group of auro-argentiferous veins in which silver predominates.[2]

[1] The gold of Mount Morgan, $\frac{991}{1000}$ fine with $\frac{3}{1000}$ of copper, is a wholly exceptional product.

[2] Let us notice on this point the idea recently suggested by the study of radium according to which frequent associations of a rare with a common metal (silver and lead, gold and silver, gold and copper, etc.) are the product of a spontaneous and continuous transformation which has operated through geological ages upon a metal originally single. Speculation has even been rife as to whether the proportion of silver to lead and of gold to copper or iron in a deposit would not allow us at once to calculate in years the age of the silver or gold, or whether, in analysing pieces of gold of known date, indications of evolution could not be found in the nature and proportion of the accessory substances. But, admitting that there is some truth in this very bold hypothesis, its geological conclusions are hardly accurate, and too many other far more essential phenomena would obscure this one. In fact, the greatest abundance of precious metals, which is supposed to

The association of gold with pyrite, or sulphide of iron, is so constant and so characteristic that it is enough to mention without enlarging upon it. This pyrite is in rare cases replaced by pyrrhotine.[1] It is often accompanied by other complex sulphides, which may themselves be auriferous, the most important being chalcopyrites. When gold is accompanied by pyrites, it is in the pyrites themselves that gold, as a rule, is to be found. For instance, in California mechanically formed pyrites contain as much as five ounces of gold to a ton and sometimes even more. Extremely minute grains of gold[2] are disseminated in this pyrite without seeming to combine with it, and in certain cases speculation has arisen as to whether pre-existing pyrite has not played the part of a precipitating reagent on auriferous solutions which subsequently came into contact with it.

Lastly, quartz, in spite of all the efforts made to distinguish auriferous from sterile quartz by general and constant characteristics, may in lodes of gold take very different aspects to which the only individual mark is given by the dissemination of metallic sulphides. It shows a grey tint at some depth and bossy cavities more or less rusted by oxide of iron in the

show an advanced stage of evolution, is found precisely in the particularly recent lodes of Western America, Mexico, etc. Besides, the associations of precious with common metals are neither constant nor in definite proportions. Silver often exists without lead, if only in veins of gold, and the proposed relation of gold to copper is still less common. I shall return to these relative proportions of associated metals on p. 49.

[1] *Pyrrhotine.* Magnetic sulphide of iron, often cupriferous or nickeliferous, found especially at Charters Towers in Queensland, Passagem in Brazil, etc.

[2] Particles of gold only $\frac{1}{10}$ millimetre in size have been found in auriferous quartz.

outcrops. The microscopic liquid inclusions, abundant in auriferous as in stanniferous quartz or, more generally, in the quartz of pegmatoid veins, often form lines which pass from one crystalline formation to another without interruption.

To these almost constant associations of gold others must be added, which vary with the nature of the deposits and have a more accidental character: in the case of these I shall be obliged to give rather a dry catalogue of deposits.

Gold in rocks (1 *a*) and in veins of granulite or directly derived from granulite (1 *b*) is found under conditions which, as I have said, recall the stanniferous group. It is therefore natural that we should have observed the passing of auriferous quartz into aplites,[1] pegmatites, etc., and have noticed in this quartz the ordinary minerals of granulites or the metals of the stanniferous group (tin, bismuth, molybdenum, tungsten, etc.). Tin itself is associated with gold and tourmaline[2] in the southern Appalachians; deposits of gold and tin are associated in the Onon region of Transbaikalia; the same was the case in the ancient deposits in the Central Plateau of France, and cases are very numerous where the gold of alluvia is mixed with cassiterite. Bismuth exists with gold at Falun (in Sweden), Bömmelö (in Norway), in Bolivia (a region also characterized by an affinity of copper, tin and silver for gold), at Glynn

[1] *Aplites.* Granulite of very fine grain, often associated with deposits of tin.

[2] *Tourmaline.* A borated and fluorated mineral, a frequent element in granulites.

(Lydenburg),[1] Pilgrim's Rest in the Transvaal, etc. The combination of bismuth with selenium may then be found (as at Falun) or with tellurium (as at Dahlonega). Molybdenum is found with gold and mispickel in California, the Tauern, Masinga (Mozambique) and Remolinos (Chili).

Mispickel, which is so normal an element of stanniferous lodes, is also found very abundantly in a number of auriferous deposits at Pestarena in the Alps, Bonnac (in the department of Cantal), Cheliabinsk (Ural), Kotchkar (Siberia), California, Passagem and Pary (Brazil), Santa Cruz (Honduras), Matabeleland in Rhodesia, etc.

We must also mention the frequent association of gold with tourmaline, a borated mineral, the common original relations of which with the white mica granites is well known and which I have just mentioned *à propos* of tin in the Appalachians. This association is very marked at Passagem (Brazil) where auriferous mispickel has a gangue of tourmaline, with bismuth, pyrrhotine and galena. It has also been found recently in Madagascar (Beforona), but is especially frequent in the veins of one group (1 *b*), in which copper predominates (itself often associated with tin, as is well known, in the partings of acid rocks, in Cornwall as well as in Bolivia and the Yunnan). Such are the deposits at Svartdal in Telemarken, Berezowsk in the Ural, where a very

[1] For these South African deposits *v.* L. de Launay, *Les richesses minérales de l'Afrique*, Paris, Béranger, 1903, on p. 26 of which I have given a list of the associations of gold in Africa.

rare association of gold with chromium[1] is found besides, Meadow Lake in California, Remolinos, Guanaco and Andacollo in Chili, etc.

Independently of tourmaline, the auriferous chalcopyrites are one of the most frequent forms of gold ore (Malmani and Lydenburg in the Transvaal, Kansanshi in Rhodesia, Namaqualand, Remolinos in Chili, Boundary in British Columbia and the coast of Vancouver).

In the group (1 *c*) of sulphuretted impregnations in metamorphic rocks we find gold habitually associated with iron pyrites, mispickel, chalcopyrite and, as an accessory, pyrrhotine in the Alps as well as in Central Africa and Brazil. Together with these predominating sulphides of iron and copper there often appear in these deposits, as in the preceding types of veins, some other accessory sulphides of lead, zinc and cobalt, which may themselves contain a little gold and which lead by progressive transitions to the plumbo-argentiferous group, of which I shall speak further on.

Examples of auriferous stibnites[2] (2) used formerly to be considered very rare, but in recent times they have become far more numerous and have often appeared locally, though irregularly, very rich in gold. We may mention Gravelotte in Murchison Range, the Inez mine in Mashonaland, Armida in New South Wales, Majurka and Kremnitz in Hungary,

[1] Gold is also found with crocoite (chromate of lead) and galena in Rhodesia, in the Manica (Penhalanga).

[2] *Stibnite.* Sulphide of antimony.

Krasnahora and Milesov in Bohemia, Goldkronach in the Fichtel Gebirge and, even in France, the Mine de la Lucette in Mayenne, the recently started working of which for gold (after having long continued for antimony) appears to give great promise. The same association of gold and antimony, in a slightly different form, and this time with the intervention of copper, is found in the auriferous grey coppers [1] of the Huanchaca district of Bolivia, and we shall presently see examples of plumbo-argentiferous complex veins with gold and antimony.

The type of plumbo-argentiferous lodes (3) is, as a rule, characterized by groupings of complex sulphides, of which we have already given examples in many of the above-mentioned deposits. Thus the Californian lodes may, together with auriferous pyrite, enclose galena, blende, panabase [2] and even cinnabar.[3]

At Ymir (Nelson) in British Columbia, as at Leadville in Colorado and Berezowsk in the Ural province already mentioned, auriferous pyrite is found associated with galena, sometimes with the addition of molybdenum (Leadville) and elsewhere of chromium (Berezowsk).

We shall find galena again in the auro-argentiferous group, which we shall now consider, but first we must mention the association of gold and cobalt (auriferous cobaltines and smaltines [4] of the Middleburg district in the Transvaal).

[1] *Grey coppers.* Sulphantimonides or sulpharsenides of copper.
[2] *Panabase.* A form of grey copper: sulphantimonide of copper.
[3] *Cinnabar.* Sulphide of mercury.
[4] *Cobaltine.* Arsenio-sulphide of cobalt. *Smaltine.* Arsenide of cobalt.

As an example of an auro-argentiferous vein (4) I shall first mention the famous Comstock lode in Nevada, the ores of which in the part worked were chiefly of altered argentiferous forms, but at a depth contained galena, blende, etc., with pyrites and chalcopyrites. In Custer County in Colorado, besides these sulphides, tellurides appear which mark the migration into the deposits of the following group. In the Thames group in New Zealand stibnite, that is antimony, is joined with these complex sulphides. In Europe the famous mines of Schemnitz (Hungary) and those of Transylvania likewise present marked examples of this form of deposit. At Schemnitz stibnite, panabase, cinnabar and fluorspar appear as accessories with the auriferous pyrites, accompanied by chalcopyrites, blende and galena, which form the principal ore. In Transylvania complex sulphides, pyrite, blende, galena, mispickel, chalcopyrite, grey copper, etc., are sometimes found with gold, and sometimes tellurides in addition.

Finally (5) the tellurides of gold, associated frequently with silver or mercury, which once seemed an exceptional mineralogical form, play to-day the chief part in some of the greatest deposits in the world, such as Cripple Creek in Colorado and Kalgoorlie in West Australia, and I have just mentioned the cases of Custer County in Colorado and of Transylvania. These tellurides, as at Cripple Creek (Colorado) and Mount Judith (Montana), sometimes show a very marked association with fluorite.

The tellurium associated with gold is not necessarily an element of superficial strata, and, consequently, of recent deposits. Telluride also is noticed in certain ancient deposits, which have crystallized at some depth in the form of impregnation (1 *c*) in the metamorphic strata, and in this case with the ordinary ores of this group, chalcopyrite, mispickel and bismuth, as for instance in the deposits of the Appalachians, which are considered to be of the Carboniferous age (King's Mountain, N.C., Dahlonega in Georgia, White Hall in Virginia, etc.). Certain ancient veins in Telemarken likewise contain a little telluretted bismuth with auriferous chalcopyrite and tourmaline. So also, at Bömmelö, gold is found with telluride of bismuth.

I have already pointed out that in this group mercury appears, as one might expect in crystallizations regarded by us as superficial. At Kalgoorlie we have especially sesqui-tellurides of gold, silver and mercury, called by M. Carnot coolgardite and kalgoorlite.[1] The association of mercury with gold is also found in California, at Bendigo (Australia) and in the republic of Ecuador.

Finally, we must mention the occasionally large percentage of selenium in certain auriferous lodes, notably those of Redjang Lebong, in the south of Sumatra, which are in relation with andesites. The selenides of bismuth at Falun show us ores of gold. Besides, selenium is very frequently found with

[1] *Ann. des Mines*, May, 1901, p. 530.

mercury, without the intervention of gold (Clausthal, Utah).

To sum up, we are led to include in the metallogeny of gold practically all the metalloids to which we ascribe the part of mineralizing agents. There is first the group of chlorine and fluorine. The intervention of fluorine is often well marked by abundance of fluorite, notably in the veins of the telluride group (Cripple Creek and Kalgoorlie). That of chlorine is never so well defined in metallogeny, because chlorine, by precipitating its metal to combine with alkalis or chalks, forms soluble salts which have been at once eliminated. But it is made very probable by the importance of chloride in the chemistry of gold, by the peculiar solubility of the metal in this form and by the instability of this chloride, which must have helped to distribute finely powdered gold in so many different deposits.

The association of gold with the sulphur group is no less marked. Pyrite of iron is a constant companion of gold, and I have insisted above on the equally frequent associations of gold with tellurium and selenium, which are chemically comparable to sulphur. We have also seen how often gold is associated with arsenic or antimony (mispickels and stibnites).

Finally, it would not be impossible, though we have no direct proof of it, that carbon itself should have intervened in the form of cyanide; at least, we see the traces of boron, an element in some ways similar to carbon, in the abundance of

tourmaline, a borated mineral, which I have mentioned above.

If we now return, in order to specify the phenomena quite clearly, to the most characteristic of the deposits which have been mentioned, we shall first insist upon what we have said of the relations between gold and either the deep granitic rocks of the ancient deposits (A), or the volcanic eruptions in the more superficial and recent deposits (B). Passing then to the mineralogical associations, we shall come to the essential forms of primary deposits which play a wholly predominant part in practice, the auriferous iron pyrites (C), more specially the pyritous conglomerates of the Transvaal (D), and the tellurides of gold (E) to show their ordinary form and distribution.

A. THE RELATION OF GOLD WITH THE GRANITIC ROCKS.—The inclusion deposits,[1] in which one can be certain that gold has not been introduced into the rock at a later period by secondary reaction, are very rare. Certain granites in the Mexican Sonora, the Cordillera of the Chili coast and the environs of Ekaterinburg (Ural) have been mentioned as auriferous, but it is noticeable that gold, like tin, separates itself from such rocks to enter into the pegmatites and aplites which are derived from them, and still more into the quartzose veins of these pegmatites.

The deposits of Um-Rus in Egypt and those of

[1] These deposits are, I repeat, those in which gold has crystallized in an eruptive rock, in which it is found existing in the same manner as the other constituent minerals of the rock.

Mazoé in Rhodesia[1] seem to belong to this type, of which the most frequently quoted examples are those of Telemarken in Sweden and Berezowsk in the Ural. In Telemarken, at Näsmark, the veins of auriferous quartz cut into steps a vein of granite, to the interior of which they are limited. At Berezowsk, in certain veins of microgranite, which themselves cut talcose schists, there are numerous very thin veins of auriferous quartz containing various sulphides of copper, lead and bismuth with gold, chromium and tourmaline, and the granitic mass from which the microgranites are derived appears itself to be auriferous. In Transbaikalia, in the Onon group, the gold appears to come from auriferous aplites traversing the granite, in which deposits of tin are also found.[2] The lodes of Cheliabinsk form numerous quartzose veins in the stratified granite. The celebrated lodes of California also appear to be in direct, though perhaps not immediate, relation with a recent granite, the contact of which in the schists they have often followed. Those of the colony of Victoria (Gympie and Swiftscreek) have joined with diorites,[3] etc. Likewise, according to M. Levat, the diorites of labradorite[4] in Guiana, with which certain placers would seem to be in relation, often enclose in their mass as much as 5 per cent. of auriferous iron pyrite.

[1] L. de Launay, *Les richesses minérales de l'Afrique*, pp. 105 and 120.

[2] Glasser, "Les richesses minérales de la Sibérie" (*Ann. des Mines*, 1900; *v.* the map on p. 32).

[3] *Diorite.* A rock of granitic structure, but of a basic composition formed of felspar and amphibole.

[4] *Labradorite.* Plagioclase felspar.

M. Bernard considered that the very abundant gold of the ancient Franco-Brazilian Contesté came from pyritous granulites united with quartz traversing metamorphic schists and amphibolites.

In another slightly different and perhaps more disputable case, the relation of gold with another group of rocks, rather less deep-seated, has been pointed out. In Spain, in the Sierra de Peñaflor, it may be concluded from the observations of M. Noguès that in the Tertiary age there were contact formations along the dioritic rocks similar to those of the Banat district, Transbaikalia, etc., with development in the calcareous rocks of silicated gangues and isolation of sulpharsenides of iron, copper and nickel accompanied by magnetite, the whole, by alteration of the diorites and amphibolites into red earths, having formed gold ores which contain some tellurides.

Finally, it seems proper to mention in this connexion the presence of gold in the metamorphizing cement of certain gneisses, like those of Madagascar, a cement to which a granulitic origin may be attributed. The introduction of gold into the metamorphic strata in which we observe it seems often to have been connected with the metamorphism itself. It is thus that gold must have penetrated the cement of the gneisses or, as elsewhere, deposited itself as a coating on the talc schists in pyritous lenticles almost interstratified in the amphibolic or micaceous schists. This hypothesis fits in well with what has been observed in so many metamorphic regions

(whatever their real age) where, as in Scandinavia, Canada, the Alps, Siberia, etc., impregnations of auriferous pyrite are found disseminated.

Perhaps the mysterious deposits of the Rand in the Transvaal, of the extraordinary productivity of which we shall have much to say, are themselves a similar case of auriferous impregnation in the banks of conglomerate. On the other hand, a relation similar to that which we have just mentioned between gold and the deep granitic magma seems, as we have already seen in a general way, to occur between the same metal and the more superficial rock formations.

B. THE RELATION OF GOLD WITH VOLCANIC ROCKS. —When we examine certain regions of auro-argentiferous veins in western America, such as Comstock in Nevada, Custer County in Colorado, or the majority of the Mexican lodes, we see a clear connexion between these veins and the volcanic eruptions which are manifested by the neighbourhood of emissions or flows of lava. Sometimes this connexion takes very curious forms. Thus at Bassick (Custer County) Mr. Emmons has described a kind of elliptic metallized column of 8—20 yards in diameter and over 400 yards in depth, which traverses the andesitic[1] breccias with clear demarcation from them and in which the sulphides of lead, zinc, antimony and copper, cementing the blocks, contain gold and silver. This curious phenomenon is not dissimilar

[1] *Andesite.* A type of volcanic rock, characterized by microscopic plagioclase felspar.

to that found at Cripple Creek in Colorado, in a district where volcanic phenomena have a still more superficial character.[1] In the Portland mine there is a chimney in the basalt 4—5 yards in diameter and over 300 feet in depth, in which basaltic detritus is incrusted with auriferous tellurides.[2] Besides this peculiar deposit, there exist at Cripple Creek, a centre which presents the clearest example of a gold deposit with volcanic relations, very numerous fissurations, often without well defined walls and with complex foliations, and associated with auro-argentiferous tellurides, such as sylvanite and accessorily pyrite (less frequent here than in most auriferous districts), a little galena, blende, stibnite and a gangue of fluorite. Gold and silver seem to exist here in almost equal quantities. The ores are deposited in the veins in columns, the most productive of which are on the circumference of the volcano, towards the boundary of eruptions and Primary granite.

By a phenomenon easily explicable on our hypothesis, these deposits which we regard as superficial and of volcanic origin in most cases present their ores in their fissures similar to those which characterize mechanical deposits, and very different to the crystallizations in large masses which are found in the deeper lead veins. These large fractures, in

[1] The eruptive rocks called *phonolites*, very rare in the United States, appear in the neighbourhood of this Cripple Creek deposit and in the Black Hills of Dakota.

[2] Etienne—A. Ritter, "Le district aurifère de Cripple Creek" (*Ann. des Mines*, April, 1905).

their superficial portions, would no doubt not have lent themselves to the crystallization of these elements, which are easily soluble or easily kept in solution by powerful agents.

In Transylvania and most of the other deposits of telluretted gold ore, to which we shall have to return, the relation with the Tertiary eruptive rocks is equally evident. It seems, however, that an exception should be made for a now classic deposit of tellurides, that of Kalgoorlie in Australia, where the deposits in their deep form are in quartzose veins of pyrite and tellurides of gold arranged in interstratified bands in the amphibolites.

C. PYRITOUS DEPOSITS OF GOLD.—The pyritous deposits of gold, in which it is associated with sulphide of iron (sometimes arsenical or cupreous), form the larger part of the primary gold deposits, and till the recent discovery of very important ores in which gold is associated with telluride, they furnished practically the whole output of the world, either in the direct form of auriferous pyrites with invisible gold, or in the altered and superficial form of native gold, which played an important part in ancient times and of which we shall have to speak again in considering secondary deposits, or, finally, by the alluvia which had borrowed their elements from them. The other associations of gold mentioned above have chiefly a theoretical interest, and up to now have only produced gold in very exceptional cases. However, before passing to the description of pyrites, utilized

as gold ores, it must be remarked once more that in the case of a metal so rare, so precious, and, in consequence, workable where its traces are so faint and its combinations so costly to treat, the exceptional mineralogical types should never be neglected, for their importance may increase largely in the future. This is what has happened in the case of the tellurides, once simply a collector's curiosity, from which to-day more than six million pounds sterling a year are derived. This remark is the more worthy of note because gold is usually invisible in its primary deposits, so that it is only found in places where it is definitely looked for or where a sufficiently minute chemical analysis is applied to find it.

The pyrites of iron form the great source of gold in most of the deposits worked at all continuously and in mines of a certain depth. While other ores, notably the tellurides, often have a precarious character and are localized in narrow fissures, which soon become wedged in as they descend, iron pyrite permeates all the depths to which our mines can penetrate, and forms, in consequence, the great reserve of gold on which we have to count for the future. It is, for instance, from pyrites that all the Transvaal gold is extracted, and almost all that of Australia, California, Alaska, Montana, Mexico, etc.—in a word, of all the great gold centres of our time with the exception of two, Cripple Creek in Colorado and Kalgoorlie in West Australia, where the gold is in tellurides. It is also under the form of auriferous pyrites that traces of gold are disseminated in the mass of our rocks, traces

insignificant in themselves, but which, when multiplied by the cubic content of a whole mountain chain give the large figures of which we shall presently read representing the percentage of gold in the earth's crust and the seas.[1]

By no means all pyrites contain gold, and they contain it in very unequal quantities, though without exceeding a very small maximum, to which we shall return. Nor is gold the only metal contained in these pyrites, which represent the crystallized product of some great sulphuretted molten mass, held for a moment in solution by alkaline sulphides, in which, as the case may be, gold, silver, platinum, copper, even tin and sometimes cobalt have been deposited along with the predominant iron. These pyrites are a frequent and common element in the substance of rocks and strata. The ease with which they are again set in motion by solution in sulphate of iron and by deposit and recrystallization in the presence of a reducing substance (organic or otherwise) has contributed to their dissemination in the majority of strata, as they were already distributed in the majority of rocks. There also exist very large masses, the cubic content of which may reach 200 million tons, as at the single point of Rio Tinto (southern Spain); and as certain of these pyrites are worked and treated, independently of the gold or silver they contain, by reason of the presence of one of the other metals that I have just mentioned, copper, nickel, etc., there

[1] P. 69 *seq.*

results indirectly a by-product of the precious metals which is not to be neglected.

In order for a pyrite, properly speaking, to be regarded as a gold ore, it is naturally requisite that the value of the gold contained should exceed the expenses of extraction and treatment, which vary in different places. A point on which I have already had occasion to insist, and on which I shall again say a few words, is that this question of the cost price is the only one which, at a given time, settles what pyrites are to be regarded as gold ores, and a decrease in that cost price may cause great masses of pyrite, neglected till now, to be taken into account.

If we take, for example, the pyrite of southern Spain which is worked solely as copper ore, we see that it may contain, for 3 to 4 per cent. of copper, 1 to 2 ounces of silver and up to 1¼ dwt. of gold a ton (Lagunazo). At Rio Tinto analysis of exported ore has given for the ton of pyrite: 98 lb. of copper, 1¼ ounces of silver and 13·76 grains of gold with 9·87 lb. of bismuth, 6·40 lb. of zinc, 1·33 lb. of cobalt and ·26 lb. of lead. These percentages have only been noticed here because the deposit had been worked for another reason, and they have only an insignificant value in themselves. It will be noticed that the amount of 13·76 grains of gold to a ton would give for a mass of 20 million tons, if gold were contained throughout and could all be extracted, 178 tons of gold worth 24·52 millions. This calculation, to which no practical importance must be attached, only aims at showing the effect of great masses, to which not enough

attention is paid when it is a question of their average composition. The extreme diffusion of pyrite through the strata and rocks, and the frequency with which traces of gold are found in these pyrites are sufficient to explain the apparently paradoxical figures, to which we shall presently come, representing the total quantity of gold contained in the upper parts of the earth's crust.

The pyrites regarded as real gold ores and worked as such naturally present themselves, as a rule, in more favourable conditions and with larger percentages of gold. This percentage depends on the greater or less facilities which the ore may offer for treatment and the extent to which the process of picking can be carried, that is, to which the poorer and more abundant ores can be used. The result is that in particularly favourable cases it has been possible to treat for gold pyrites in which the percentage contained was hardly higher than that of Lagunazo mentioned above. The mines where this limiting percentage is lowest are those of Treadwell in Alaska, where ores have been worked containing on an average 8*s.* 4*d.* a ton, or hardly 46 grains, and Homestake in Dakota where in the enormous works, to which we shall return, ores are treated worth 15*s.* and costing 10*s.* a ton to treat, thus allowing ores containing 60 grains to the ton to be utilized. These are exceptional cases. In such important and widely opened mines of non-refractory ores, 60 grains to a ton may suffice, but much more often 105 or 120 are necessary. In the Transvaal pyrites containing 105 to 150 are ordinarily treated.

It will perhaps seem to those who have not fixed their attention on our preliminary remarks about the difference between ore and barren[1] rock, that I am defining the amount of gold in auriferous pyrites in a very imperfect manner, and they would no doubt wish me to fix that amount at a figure independent of industrial conditions, as can be done, for example, with the proportion of copper in chalcopyrite, which when it is pure is $\frac{1}{3}$, or with galena, which under the same conditions contains 86·6 per cent. of lead. But I repeat that auriferous pyrite is not a definite chemical and mineral substance of invariable composition, like the sulphides of lead and copper; it is a mixture in which the amount of gold starts at zero to reach locally, but solely in the altered forms, 100 per cent. in crystals of native gold. However—and this has a certain interest for the origin of gold—when superficial alteration has not intervened to concentrate the gold subsequent to its primary deposit, the gold in pyrites never exceeds the very small proportion of ·26 to ·39 lb. to the ton of prepared pyrite. There is, in spite of all, a sort of definite proportion similar to that which for silver (almost always associated with sulphide of lead, as gold is with sulphide of iron) imposes, as a rule, a limit of 5 lb., and keeps it more usually under $2\frac{1}{2}$ lb. to the ton. A certain number of other proportions more or less definite are known between metals commonly associated, the theoretical explanation of which (for a moment thought to be found in the evolution of matter[2]) will

[1] *V.* p. 3.

[2] *V.* p. 30, note 2.

doubtless one day be discovered. Thus in the pyrrhotine mines of Canada we may have 1 of platinum to 50,000 of nickel, and 1 of gold to 250,000 of the same metal. In other groups also sulphuretted we may have 1 of gold for 25, 50 or even 100 of silver, and 1 of silver for 1,000 to 5,000 of copper or lead.[1]

Yet it is only a question of averages, and it must by no means be imagined that the composition of an auriferous pyrite is constant; on the contrary, it may be extremely variable and now one, now another, of the accessory metals just enumerated may be seen to develop in it, in various cases, in an absolutely incidental manner, which seems to escape any theoretic law. These accessory metals may sometimes make an increase of profit, but they may also prove a hindrance, and miners distinguish gold pyrites with the utmost care according as they contain directly amalgamable gold, or gold easy to treat by cyaniding, or gold, on the other hand, involved in complex combinations which make treatment by mercury as well as by cyanide of potassium ineffective and which require processes much more complicated and costly, though even they are sometimes impotent to extract all the precious metal revealed by chemical analysis.

The forms of deposit in which sulphides of iron or copper, sometimes arsenical, containing gold are treated are very different. Auriferous pyrite may present all the types of deposit recognized by theory from simple inclusion or a patch of ore in the mass of a rock, passing through segregated pipes in contact

[1] *La Science Géologique*, p. 663.

with the same rock, injected bands, interstratified impregnations, pyritous zones, etc., which seem to represent deep-seated crystallizations, to lodes proper, which have risen nearer to the surface. The types of injected bands and impregnations especially are extremely diversified; the solution of auriferous sulphide must have penetrated under pressure into strata, ordinarily schistose, of which it has incrusted all the cavities, filled all the interstices and joined all the gaps. The possibility may further be conceived of a sedimentary pyritous deposit in certain basins of concentration or on river banks, where great sulphuretted masses have begun to be brought up after the destruction of the pre-existing deposits. It is perhaps to an origin of this kind that the pyritous ores of conglomerate worked in the Transvaal should be attributed, unless we are to see in them, as I shall state, the product of an incrustation subsequent to origin in veins, or of an hydrothermal sheet which has penetrated at a depth into the interstices of a conglomerate as into the fracture of a vein.

D. AURIFEROUS PYRITOUS CONGLOMERATES.—The type of auriferous conglomerates represents a very special form of deposits, the importance of which has become enormous, since the Rand with such ores has alone produced over 24 millions a year, and yet, in spite of a vigorous working, the real origin of them is not perfectly known. In some countries (especially in the Rand and to some extent in West Africa) the ores take the form of interstratified beds in the midst

of strata either barren or poor in gold, of undetermined though certainly Primary age. Their practical form is that of sedimentary deposits following all the curves of the enclosing strata and apparently without immediate relation with any eruptive rock or any lode proper. In these beds, of which on the Rand a number varying from one to five can be profitably worked at the same point, conglomerates, or "bankets," are found, that is to say rocks formed of quartzose pebbles rolled up and bound together by a siliceous cement in which auriferous pyrite is incorporated. The pebbles by themselves are barren; the auriferous sulphide is solely concentrated in the cement, and the metamorphism of the whole has been such that it is all welded and recrystallized together. The size of the pebbles in any given bed seems to have a certain relation to the amount of gold. The thickness of the banks, or "reefs," of auriferous pyrite goes from 7 to 8 yards for the *main reef*, which is always comparatively poor (75 to 225 grains of gold to a ton), to ·20 yards in the thin veins called the *main reef leader* or *south reef*, which are principally worked. Similar auriferous beds are known in a region about 125 miles long by 31¼ miles broad round the town of Johannesburg; but almost the whole of the present output, in the difficult conditions with which this great industry has had to contend since the Boer War, is concentrated in a very small corner of the district, about 9½ miles long by 1¼ to 2 miles broad; the rest is a reserve for the future.

These ores are generally very poor. They are

worked to-day down to a yield of 105 grains of gold (17*s.* 6*d.*) to the ton, which balances the mean cost of extraction; the current amount, in practice, varies from 225 to 450 grains; higher amounts of 1 ounce or £4 have only been obtained locally. The pyrite which contains the gold is remarkably pure from other metals, though traces of lead, copper, etc., may be found in it.

To explain these ores two main theories have been propounded. The one most generally adopted regards them as the product of an auriferous impregnation which, under the form of a hydrothermal solution, has intruded at some depth and under pressure into previously deposited strata of sandstone and pebbles. This solution has then taken this form of banded vein, a frequent characteristic of aquiferous—especially of hydrothermal—sheets, which are sometimes looked for by soundings in similar conditions: it has followed the bands most favourable to its infiltration, in which the size and disposition of the pebbles gave it greatest facilities, and the whole, held at first in solution by the alkaline salts under pressure, crystallized at a given moment. It is certain that in other countries increasing numbers of cases are becoming known in which strata variously metallized and formerly considered to be pronouncedly sedimentary have with great appearance of probability been so explained as veins. Nevertheless, another hypothesis may be assumed which I have already mentioned: that great masses of auriferous pyrite have been set in motion in the basin where the

conglomerates were deposited by the destruction of a whole mountain chain containing lodes of gold, which we know to have existed in Primary ages. Then this pyrite with the gold enclosed has concentrated chemically or mechanically in the shallower parts, the littorals of the water where the conglomerates were accumulating, and finally a saturation took place, causing the precipitation of the auriferous pyrite, which was subsequently recrystallized by metamorphism.

The conglomerates of the region of Takwa in West Africa present similar characteristics with a much smaller proportion of gold and, as a rule, less easy to work.[1]

E. TELLURIDES OF GOLD.—The type of gold ores associated with tellurium was till a few years ago only a mineralogical rarity. Now these ores hold the first place in two of the principal present deposits, Cripple Creek in Colorado and Kalgoorlie in West Australia, with which the previously known but less important deposits of Transylvania may be joined. At Cripple Creek a recent volcanic district, in which the presence of a still intact volcano is recognized, has been traversed by numerous rocky lodes and a whole network of auriferous veins connected with these rocks. These veins are often almost closed, very precarious and very thin, but are succeeded in the enclosing rock by an impregnation band which itself is also an ore. The tellurides of gold are associated with sulphides of lead, zinc,

[1] For a more detailed description of these deposits I refer the reader to my two works, *Les Mines d'or du Transvaal* and *Les Richesses minérales de l'Afrique* (Paris, Béranger, 1896 and 1903).

copper and antimony in a gangue of quartz and fluoride of calcium. The enrichment follows columns, or pipes, which the Americans call "shoots," the breadth of which varies from an inch or two to several yards with a length which may reach 150 yards. The discovery of gold dates from 1890, and in the single year of 1897 2·76 millions were produced, and 3·12 in 1904.

At Kalgoorlie in West Australia, sedimentary strata composed of schists, quartzites, etc., with diorites and schistose amphibolites have been cut by numerous series of displacements which are traversed or succeeded by lodes, or "reefs," containing tellurides of gold with various sulphides of lead, copper, etc., and, in the higher parts, free gold. The ordinary amount of gold runs from 1 to 4 ounces a ton in the utilizable parts, but may locally attain 1 lb.

§ 3.—*Deposits of secondary concentration—Chemically altered ores—Lodes of native gold—Red earths and laterites.*

The forms of auriferous deposits which remain to be studied have up to now played an altogether preponderating part in gold-mining, and it is only very recently that the poorer original deposits previously described have begun to be attacked, the working of which will be the principal resource for the future. Gold, which is everywhere one of the most anciently sought-for metals in the whole world, if not the most anciently known, is a metal the deep-seated forms of which have the longest escaped discovery. In fact,

we must not lose sight of the extraordinary smallness of the proportions, a pennyweight or so to the ton, which the majority of gold deposits give us. If a superficial concentration had not locally enriched them and deposited gold in them in the form of native metal which at once attracts attention, these rocks, in which only very careful chemical analysis or very minute microscopical examination could reveal gold, would have had no reason to be noticed. It was necessary that examination should have been provoked and localized by the previous discovery ot "placers" or "caps" of lodes to start the idea of seeking for gold in most of the deposits which are worked to-day.

The phenomenon of secondary auriferous concentrations, of which we now have to speak, seems, in general, wherever it has produced deposits of any value, to have operated in several successive epochs by the intervention of chemical reactions combined with mechanical preparations, and that is why secondary deposits of great richness may come from very poor and industrially unworkable primary deposits.

In this section we shall only consider chemical alterations, and mechanical changes will form the subject of the following section.

In principle, these chemical alterations, confined as they are to the neighbourhood of the surface, or rather to the region where water circulates easily, which is limited in depth practically to what is called the *hydrostatic level*, have great practical importance

for metalliferous deposits. In a number of cases there exists above, and sometimes a little below, this hydrostatic level, a region of enrichment which may begin from the exposed surface. In uneven country where the hydrostatic level is sometimes several hundred yards below the outcrop of the vein this enriched, or at least transformed, region occupies all the practically utilizable parts of the vein, and therefore gains an overwhelming industrial importance. In the majority of mines, when we get below we find a sharp change in the mineralization, the industrial consequences of which, if they have not been foreseen, may be grave. As far as gold is concerned what happens is, briefly stated, as follows.

Let us again take up the history of a lode of gold at the moment when, after its original deposit, its highest part is for the first time brought by the progress of erosion into contact with the superficial stream of water. The property of such streams, which are constantly recharged by their very circulation with oxygen, carbonic acid and other mineral principles common to surface waters, such as traces of chlorides, nitrates, etc., is to exert an oxidizing and dissolvent action upon the sulphuretted ores. Applied to auriferous pyrite this reaction produces sulphate of iron and soluble gold salts. The sulphate of iron in the topmost parts of the deposit is immediately precipitated under an oxidized form and constitutes what is called the ferruginous "cap" of the lodes. The dissolved gold may be partially drawn out and lost (thus going to enrich the placers, of which I shall

speak further on) ; but a large part descends with the waters along the lode and is precipitated on its deepest parts, enriching them under the form of free or native gold deposited in all their fissures.[1]

Let us now imagine such a reaction continuing during entire geological periods upon deeper and deeper parts of the lode, which are successively brought to light by the progress of erosion.[2] It is easy to conceive how, besides a portion of gold drawn chemically or mechanically away and destined to form alluvia, growing quantities of gold have been accumulated in the remaining altered region, especially in its lowest part, near the hydrostatic level, where the reprecipitation chiefly occurs. The conclusion is, therefore, that an altered deposit presents when completely filled, going from top to bottom :—(1), a cap of hydrated sesquioxide of iron often rich in native gold ; this is called the region of peroxidation ; after which comes (2) what is called the region of cementation, or of "bonanzas," that is to say, exceptional productivity, in the language of American miners. There with a residue of untouched sulphides, ores of native gold exist which may be very rich locally following the chimneys, or "shoots," along which the circulation of water chiefly went, but which are

[1] The dissolution of gold is, contrary to the general idea, a very ordinary phenomenon, and examples are known (Taupo in New Zealand and Steamboat Springs in California) of hot springs depositing gold and silica in the neighbourhood of the surface.

[2] Faults play a very important part in these introductions of superficial waters. On the occasion of a recent work, *La Metallogénie italienne* (The Geological Congress of Mexico), I analysed several cases of this kind. We must take account also of ascending or thermal springs.

always very irregular and certain to disappear at some depth. Finally (3), when we penetrate sufficiently deep, we almost always find the original pyritous type, in which the gold is in a state of mixture or more or less complex combination with various metallic sulphides, and which keeps the same aspect to the end of the deposit.

It is the enriched ores of the two first regions, but chiefly the region of cementation, which furnish the beautiful fragments of milky-white quartz through which gold seems to ooze or grow like a plant out of all the fissures, and which the English compare to a "jeweller's shop." Most extraordinary proportions of gold may be found, up to blocks of native gold; but this is not a type of deposit on which we can count for the future, and as it is a superficial class of ores, without deep-seated continuation and easy to recognize, the deposits of this kind decrease every day in importance, and are doomed in a not far-off period to disappear completely. Despite the fascination which they exercise, it is not these, but the poor and regular ores of the deeper strata which give the large returns. Roughly speaking, the lower limit of these "bonanzas" would seem to be at the hydrostatic level, which may be complex and compatible with the reappearance of oxidized parts below unaltered parts;[1] but, as the American geologists, Mr. Weed, Mr. Emmons, etc., have shown by numerous and interesting observations,

[1] I do not here speak of movements of the soil. I have long ago called attention to the probable part played by them in certain alterations which go very low, and Mr. Weed has given examples at Butte City (*Genesis of Ore Deposits*, 2nd edition, p. 497).

the reprecipitation of gold, the cementation, and therefore the bonanza, can descend far below the hydrostatic level, so long as the circulation of water continued there. These geologists have also demonstrated that other metallic sulphides, galena for example, could not have taken the place of pyrite for this reprecipitation of gold, so that in deposits of galena without pyrite there is no bonanza.

Most mines have seen this phase of superficial enrichment in a more or less marked form, according as the alteration of the pyrite has been more or less complete. On the Rand the miners began by finding disaggregated conglomerates at a depth of forty-five to sixty feet, the pebbles of which, fixed in their beds, were often covered with an auriferous coating. High proportions of gold were then obtained which have disappeared very rapidly, and, if at the psychological moment the process of cyaniding had not been discovered, which has been applied with marvellous success to the deep-seated pyritous ores, the industry of the Transvaal, on the disappearance of the ores of native gold, might have undergone a grave crisis. In the famous Californian lodes, at depths of 120 to 180 feet, proportions of free gold have been found in the "iron cap" which frequently reached 4 to 5 ounces. Lower down the proportion fell, and quartz with auriferous pyrites and sulphides of all kinds was found: the proportion of gold in the ores fell to 225—300 grains, while the proportion of gold in mechanically prepared sulphides was from $3\frac{1}{2}$ to $4\frac{1}{2}$ ounces. Finally in Australia, in the equally celebrated Mount

Morgan (Victoria), altered and irregular ores with silicified peroxide of iron were found as far as 270 feet down; the proportion of gold increased from the surface towards the region of cementation where it reached $3\frac{1}{2}$ ounces; lower down quartz with auriferous pyrite was found, the proportion of gold in which soon descended to 1 ounce and lower.

Outside the foregoing examples, this successive alteration and change, which have occurred in very many lodes, appear to me to have been of exceptional practical importance when, in place of already distinct lodes presenting in their own mass a region properly disposed for enrichment, there have been very numerous impregnations disseminated in the metamorphic strata, like those which I mentioned above, that is to say, when erosion has laid bare sufficiently deep parts of the crust to expose these metamorphosed parts to alteration. Such a phenomenon of metamorphism has commonly occurred in the anciently plicated parts of the earth's crust. Even the ancient gneisses, in this connexion, show an extent large enough for people to have believed for a long time in the great age of all gneisses. The exposure of such strata where they have been pyritized by auriferous pyrite has at once caused the mechanical and chemical displacement of the gold contained; one part of this gold went directly to form placers, another descended, as we have just seen, in a state of solution following the shape of the veins or penetrating adjacent fissures, and produced auriferous veins already enriched, the subsequent

destruction of which by erosion has caused an enrichment of the second degree.

The necessarily superficial character of such veins enriched by alteration even gives reason to suppose that in certain regions, where subsequent erosion has been great, and where auriferous placers have been found, the veins themselves have been completely and radically worn away, so that we perceive no trace of them, or, at least, so that the remaining deposits of this kind do not seem proportionate to the corresponding auriferous alluvia.

It is important to notice this, for the veinules or pyritous impregnations of metamorphic strata, without proper lodes, should play a preponderating part in a certain number of ancient "wedges" of rock[1] in which the abundance of gold concentrated secondarily by alteration *in situ* or by alluvium, has aroused the hope, probably to a large extent illusory, of finding well developed primary deposits.

This seems to be the case almost all along the Siberian mass, in that of Brazil, which is continued by Guiana, of Central America, Madagascar, Scandinavia, etc., all regions in which we observe plateaux plicated many years ago, eroded and altered during a long period, with deep-seated strata exposed. In the most northerly of these ancient masses the concentration of gold has only occurred through alluvia. The rocks, ploughed up by the passage of glaciers,

[1] The French word is *voussoir*, which means the wedge-shaped stone of an arch. M. de Launay tells me that he means the most anciently consolidated portions of the earth's crust, which are like independent wedges of rock (Translator).

do not, in fact, show any very deep-seated alteration. In the equatorial zone, on the other hand, alteration *in situ* has been the chief influence, with its argillaceous and ferruginous residues (laterite, red earth, cascajo, *terre à ravets*), in which a chemical enrichment has occurred *in situ*, sometimes followed by a mechanical alteration. The *terre à ravets* of Guiana very often contains, besides the almost microscopic threads of gold which are the principal element, large nuggets, and sometimes nuggets covered with a ferruginous coating, which would cause them to be taken for blocks of iron oxide.

In the ancient Franco-Brazilian Contesté, as we have already seen, metamorphic strata with amphibolites predominating are traversed by veins of granulite which has contained iron pyrite. These pyrites have given oxides of iron or of manganese in the outcrops, with free gold in the decomposed strata.

In Brazil, in the province of Minas, great masses of oligist iron ore or itabirites are found, which are sometimes worked for gold (at Gongo Socco and Morro de Santa Anna). There the gold also impregnates the fissures of the quartzites, the surfaces of the micaceous schists, and may even be found in true quartzose lodes in which it has simultaneously been isolated by alteration and precipitated in the native state.

§ 4.—*Deposits of secondary concentration (continued)—Mechanically prepared ores—Auriferous alluvia—Placers.*

I have already explained why this form of deposits, which is the widest known, the most striking to the

imagination, and the most seductive in the first blush, tends little by little to disappear, and will be of no more account in a few decades when civilized man has completely taken possession of the earth.[1] These ores are, in fact, the very recent result (hardly previous to the appearance of man) of an erosion by which the rocks and lodes have been dismantled, crushed and concentrated, most probably both mechanically and chemically. Nature has taken it upon herself to save our pockets by carrying out for us the labour which, under other circumstances, we are obliged to perform with difficulty by means of our stamps, our sieves and our shaking tables. The result is that ores very poor in themselves have been able to give productive alluvia. It would be quite erroneous to imagine the reverse to be true, that when productive placers are found the original lodes must also necessarily give industrial results. Such results are obtained (and most of the great lodes of Australia and California were found in this way) by tracing the placer to its origin; but they are rather the exception. The enrichment of the alluvium appears the more marked in practice in that it consists of a class of ores to which marvellously cheap processes of extraction, hydraulic mining for example, can be applied, thus reducing the minimum percentage utilizable to a fraction of a shilling a ton.

The phenomenon of destruction, erosion and alteration in the watercourses, which has formed the placers, has occurred at all periods in the history of

[1] *V.* the table on p. 18.

the globe, and with special intensity in the wake of the great internal movements which caused the rise of the mountain chains; these were at once subjected to destructive action in which their materials, especially the metallic parts, were classified. Auriferous alluvia have therefore been formed at nearly all epochs and, in fact, some traces of similar deposits in ancient strata are known. It is even not impossible, as we have seen, that the rich deposits of the Rand began by having an origin of this kind.[1] However, the auriferous alluvia previous to the most recent period of geological history, which begins with the rise of our latest, most lofty and youngest mountain chains, are extremely rare. The reason is that deposits of this kind, being superficial and continental to the highest degree, were immediately exposed, except under very special circumstances, to the continuation of the destructive influences which had originally formed them: they were eroded and altered in their turn, and finally disappeared, as have nearly all the continental formations, in a general way, of more distant periods. The alluvia of the Tertiary age, which may at most go back to the Eocene[2] period, have themselves undergone vicissitudes of this kind, and it is, to a large extent, the gold of the early Tertiary alluvia formed on plateaux which, being gradually changed and displaced, has descended, terrace by terrace, with the hollowing out of the valleys down to the most modern alluvia.

[1] *V.* pp. 53 & 54.
[2] The oldest subdivision of the Tertiary.

When the gold-seeker, the "prospector," enters a new district, he usually proceeds in the reverse direction to this historical evolution. He starts from the present valleys along which he begins prospecting by washing sand in a batea or pan; this first deposit exhausted, as it soon is, he then tries a higher and older alluvial terrace; then he mounts another step, and finds himself forced to use more industrial methods and to work on a larger scale. It is thus that in California the miners were brought to concentrate their principal efforts on the ancient alluvia of the plateaux, covered as they were by beds of barren rock and sometimes by flows of volcanic lava, under which they had to be sought by subterranean methods. By means of shafts and soundings very detailed maps were progressively drawn of these auriferous alluvia in which these channels of ancient rivers, to-day completely hidden from the surface, figured as actual rivers, and it is by reaching these in some manner that the working proceeds.

The most salient general characteristics of all these auriferous alluvia are as follows, taking those in California to serve as a type. There are in California, over a length of nearly 250 miles, and up to a height of 6,300 feet, more or less broad trenches filled with detritic materials, of which the oldest are Miocene, and some Pliocene.[1] These brook-like layers, in which sometimes volcanic tuffs are intercalated, and which may be covered over by basalts, rest on a bed

[1] *Miocene*, middle subdivision of the Tertiary. *Pliocene*, highest subdivision of the Tertiary.

of schists, which is called the "bed-rock," and it is usually in contact with this bed-rock that gold has accumulated, although some is found at other levels. The gold is contained in a state of fine division and associated with pyrites which, in the regions unaltered by contact with the air, have a blue tint (blue gravel), and in the oxidized parts a red tint (red gravel). The thickness varies from an inch or so to 45 feet. The percentage is very variable, going from zero to several shillings. Occasionally three superimposed auriferous levels have been found.

In principle, it may be remarked that all placers show little sign of having travelled, and are in consequence in very direct relation with the original deposits. I shall also recall the fact, because it is a disputed point, that without question chemical dissolution has interfered (always under the same conditions as stated in the preceding section, and by means of sulphate of iron) to cause the concentration of gold in nuggets of greater size than the fragments of the same metal contained in the neighbouring veins.

It has also been noticed that the very general law by which gold, as we have just seen, is concentrated for preference at the base of the alluvia, on the bed-rock, seems to necessitate the displacement of gold in the alluvium itself subsequently to its deposit, a displacement probably similar to that which, in a washing of auriferous sand, makes the denser gold descend through the barren ore to the bottom of the pan, where it is shaken up. For the same reason

gold is often intruded into the very fissures of the bed-rock to a depth of 1½ feet.

As another known type of auriferous alluvia, presenting the same general characteristics as the Californian type with some local peculiarities, we will mention the placers of the Yukon basin in the west of Canada. Near the river Klondyke there exists a series of auriferous terraces, the highest of which present at their base under sterile strata a whitish layer rich in quartz and gold, the "white gravel channel," which may be 75 feet in thickness. The gold is in little rounded foliations and amygdales. Likewise in Alaska, at Cape Nome, there is a layer of auriferous sand on the seashore, tinted red to about 3 inches down, which may extend to a breadth of 60 feet. These alluvia of the northern regions are, like those of a part of Siberia, in frozen strata.

In Siberia the placers of the Lena in the Olekma belt have a mean percentage of 45 grains and a thickness of 3—6 feet in the workable parts; in the Wittim district 150 and 210 grains are reached in exceptional cases.

In considering these percentages we must not forget our preliminary remarks on the purely conventional and simply industrial character of a "mean percentage of gold." The *minimum* percentage of gold is simply determined by the cost price of treatment, and the *mean* percentage is influenced in an unknown degree by the way in which it is thought fit to conduct operations, according as a greater or less quantity of poor ore is extracted. Since in the

majority of properly conducted mines, in a Siberian placer as well as in a Transvaal lode, exploitation is preceded by a tracing or by a series of soundings which aim at determining in advance the rich and poor regions, it is always easy, at least temporarily, to vary the mean percentage by the choice of exhausted masses. As for the maximum percentage, it depends on the possible discovery of a nugget in the region analysed, and signifies still less. The only useful means of calculation which is not geological is, therefore, the net profit realizable on a given number of tons after deducting the cost of production.

§ 5. *The percentage of gold in the continental masses and seas—The future reserves of gold—The extreme localization of large deposits.*

In concluding this geological study, in which we have attempted to arrive at what has happened in the case of abnormal concentrations of gold, we shall examine for the sake of comparison what is the normal or mean percentage of gold in the earth. We shall try to calculate this mean percentage, first, for the combined continental masses, then for the seas, the percentage of gold in which is by no means negligible. In this way we shall be able to realize the high degree of concentration in the industrial deposits, and show their altogether exceptional character. The question has the more practical interest in that, as was noticed above, it is the immense masses of poor ores or of rocks with very low percentage (by which

this *mean* percentage is reached) which are probably destined to play the preponderating part in the future workings of gold, when the few rare concentrations on which we exist at this moment are exhausted—which will occur before very long. The calculation here in question seems at first sight almost impossible, and I do not think it has ever been attempted. It cannot, in fact, be attacked directly, as in the case of a metal like iron, which is everywhere abundant, and therefore a common element in analyses. The mean of a very great number of analyses (several thousand if we like) gives us with real accuracy the mean percentage of iron in the superficial crust. But similar analyses in which gold figures are very rare. This will be at once understood if we notice that, according to the result at which we shall arrive, there is in the earth at least 2 million, and perhaps 20 million, times as much iron as there is gold, so that to reveal the second of these two metals as often an analysis at least 2 million times as minute or subtle would be necessary. We shall, however, by approaching the problem indirectly in various ways, arrive at an approximate figure, which, without any pretension to accuracy, will make us acquainted with the order of magnitudes in which we are dealing, and will allow us, above all, to arrive at some new economic conclusions on the way.

Our first means of calculation will be founded on the industrial output, starting from the very plausible notion that the outputs of two metals are, under equal conditions, in direct ratio of their abundance. To

put it in another way, let us imagine two equally accessible heaps of sand in the same place which are ransacked with the same avidity. In one ten times more metallic tailings have been distributed than in the other; it is to be presumed that ten times more will be produced from it. If the real proportion of the quantities extracted is different, it is doubtless because the facilities for extraction or the avidity of the searchers were not the same. Further, the metal ten times more rare and requiring ten times more labour for an equal weight produced will, on this hypothesis, be worth ten times more.

Let us then draw a comparison between gold and iron. The output of gold from antiquity up to 1907 may be put at some 18,000 tons, representing 2,480 millions.[1] Calculating on the basis of the annual output at ten hours' labour a day, this is practically the weight of ferruginous products (iron, cast-iron and steel) which the world produces in one hour.

The earth's crust contains on an average 4·70 per cent. of iron. If we suppose, as I have just said, that the percentages of gold and iron are proportional to their annual outputs, we arrive, by comparing the 73·2 million tons of ferruginous products with the 383 tons of gold produced in 1900, at a percentage of gold 191,100 times smaller than that of iron.[2] Thus

[1] A similar calculation, which I here reproduce for curiosity's sake, gives for the stock of diamonds counted in the rough nearly 20 tons, representing a gross value of 140 millions.

[2] In 1905 a similar calculation (85·26 million tons of iron, cast-iron and steel against 573·60 tons of gold) would show the percentage of gold 148,000 times smaller. But for the preceding years, before the great development of the present gold output, the proportion exceeds 1 : 200,000.

the mean percentage of the last few years is in the case of gold ·000024 per cent. or nearly 1 : 4,000,000. By this rough and ready way we come to the very improbable mean percentage of 3·67 grains of gold, or 8*d.* for a ton of any rock. This method brings us very clearly to a much too large percentage of gold, from which we may draw this interesting conclusion, that the output of gold is to-day too high in proportion to the respective mean percentages of iron and gold in the earth's crust, the search for it being more active and more easy. But, on the other side, it may be noticed that the mean percentage of a utilized iron ore is nearly ten times higher than the mean percentage of iron in the crust (47 per cent. against 4·7). If the proportion were the same for gold, instead of a percentage of 3·67 grains, which is sometimes almost workable, we ought to be able to find a percentage ten times less, and the real relation of the percentages of gold and iron, instead of 1 : 200,000, will be represented by 1 : 2,000,000. In any case it seems probable that it should not exceed 1 : 20,000,000. The proportion 1 : 2,000,000 corresponds to a percentage of gold of 1 : 40,000,000, or $\frac{3}{4}d.$ a ton.

On the same hypothesis, which, be it noticed, corresponds to a maximum percentage of gold, gold should be worth 2,000,000 times as much as iron, or £18,000 the kilogramme (2·67 lbs.), 130 times its real price, if we suppose, which naturally is not accurate, that the price of a metal is in inverse ratio to its rarity.

The marked divergency between the price of gold

thus calculated by comparison with iron and its real price is not only due to the difference in the cost of working; for, under the limiting conditions of treatment, which are, in fact, those of a very great number of ores, almost the same bulk of iron and gold ore must be turned over to obtain (with a singular difference in the weight) the same value as far as it represents the cost of extraction and of treating this bulk of ore: let us put it at 16*s.* a ton, to fix our ideas. It is then necessary that, contrary to first appearance, the demand for gold, proportionately to its rarity, must be less than that for iron, the search for gold mines being pushed on with an excessive activity.

In other terms, in comparison with iron, much more gold is produced than is consistent with the mean percentage in the earth, and that is why, relatively to this mean percentage (which does not mean relatively to our needs and our consumption) there occurs a sort of over-production, which causes a considerable reduction in the value to which the rarity of the metal would by itself give rise. Gold, as compared with iron, has not all the relative value which might result from its rarity. If in reality, according to our first hypothesis, quantities of gold and iron were extracted proportionate to those which the earth's crust contains, iron, which is produced in perhaps 1,000 times as large quantities, would be worth 1,000 times less, or gold would be worth 1,000 times more. The "thirst for gold" which leads to the working of so many mines at a loss, the remarkable facilities for extraction

in the placers where the gold is in a free state, and finally the possibility of obtaining gold in regions difficult of access, where other metals heavier to transport could not be worked, must contribute to this result.

Let us admit provisionally this mean gold percentage of 1 : 40,000,000 to 1 : 400,000,000. The great exceptional deposits, to which attention is violently drawn, take little part in raising this mean, which represents an enormous cubic content of rock, since men have only been able to extract 2,480 millions from these deposits against a total of 1,240 millions of millions at which we shall arrive by starting from these mean figures.

Applied at once to the surface of continents above the sea, or to 55,984,500 square miles to a depth of 5 furlongs, this mean percentage gives 9,000 million tons, or 1,240 million millions of pounds sterling, of which the 2,480 millions extracted up to now represent only $\frac{1}{500000}$th. The figures are large; yet if we notice that it is a question of the absolute quantity of gold, independently of all possibility of working, and of gold in the state of infinitesimal traces (probably under the form of auriferous pyrites), which mount up when such masses are considered, we cannot say that this result is improbable. Besides, we arrive by another way at sufficiently congruous results.

In this way the percentage of gold in the sea has been calculated with an accuracy impossible to hope for in the case of the continental rocks and strata,

which are so much more heterogeneous. This percentage has been analysed several times, and the figures obtained have been very similar. In 1872 Mr. E. Sonstadt found in sea water taken from a bay in the Isle of Man about 64 milligrammes (·98 grain) of gold to a ton. In 1884 in the Bay of San Francisco 32 milligrammes (·49 grain) were observed. In 1894 Mr. A. Liversidge obtained on the coast of New South Wales 32 to 64 milligrammes a ton. The figure of 30 milligrammes (·46 grain) or ·9*d.* a ton seems enormous, and imaginative prospectors at once took out patents to extract this gold from the sea. We have not yet reached this practical side of the question, and we are even very far from being able to affirm that this percentage (supposing the analyses of similar traces to be really accurate) is general. All the experiments have been made in the neighbourhood of coasts or near the surface. Doubtless we can see no reason why the chlorides, bromides, or iodides of gold should have remained localized on the present coasts, given the stirring which plications of the soil must have caused throughout their mass during long geological periods. However, variations of this kind may exist. Let us then, in prudence, reduce the percentage by $\frac{1}{100}$th; we are then at ·3 milligramme (·0046 grain) of gold or ·009*d.* a ton, a figure 100 times smaller than that which we have allowed for the gold in the earth. But if we remember that the seas occupy a space of 140,926,500 square miles to a mean depth of 3,946 yards, or about 366 million cubic miles, or 1,500,000 million million

tons, we are brought by the force of multiplication to prodigious results: £160,000 worth of gold to the cubic mile or 60 million millions of pounds for the whole of the seas.

In this connexion one might go a little further and use the percentage of the seas to control, in a certain measure, that of the continents. The above percentage of gold in the sea must, in fact, for the most part, come, as I have tried to show elsewhere, like all the other substances contained in the sea, from the long washing to which the materials derived from terrestrial erosion carried down by the watercourses to this "universal sewer" and finally more or less completely dissolved according to the solubility of their salts have been subjected.[1] In the case of a substance entirely dissolved and wholly drawn into the sea, its percentage in the sea, according to the calculation to which this theory leads, represents about a fifth of the mean percentage of it in *terra firma*.

Thus on this hypothesis of a total dissolution, which has not approached realization in the case of gold, and which would, in consequence, lead us to a too large percentage of gold in the seas or too small percentage in the continents, the mean percentage of the sea being ·3 milligramme (·0046 grain) or ·009*d*., the mean percentage of the rocks and earth should be 1·5 milligramme (·0230 grain) of gold or ·045*d*. to the ton instead of the 25 milligrammes (·38 grain) and

[1] *La science géologique*, p. 341. I have shown in this work how a relation between the percentage of the seas and that of the continents could be arrived at in the case of any substance.

·82*d.* which we have found; that is, sixteen to seventeen times less. Remembering that we have arbitrarily divided by 100 the percentage given by analyses of sea water, besides bringing in the fact that the dissolution has been only partial, we see that the percentage of gold in sea water leads us to regard our figure relating to the percentage of the rocks, which astonished us just now and which we were induced to diminish, as again entering into the desired order of approximations.

Let us now compare the mean percentage of 1 : 40,000,000, which we have some reason to believe admissible, with the percentage of 1 : 33,000, which is that of a rich ore, and we see that this latter is only a million times larger; that is to say that if all the gold in the earth was distributed in such ores, the rest being barren, it would occupy $\frac{1}{1000}$th of its present volume. But the question does not present itself thus. These points of concentration represent, as we have seen, only $\frac{1}{500000}$th of the total stock of gold at disposal. They only help to raise the mean percentage by about $\frac{1}{500000}$th, which can therefore be estimated independently. The gold of the largest deposits, whatever the exceptional character of its accumulation in a certain volume of rocks, only occupies, in fact, an imperceptible portion of the earth's space, being in a few very thin veins, themselves localized in a very small number of mining centres.

In this connexion one may entertain a very singular illusion on looking at one of those maps on which the metalliferous ores are marked (there are many of these for gold). On such a map the number of gold mines,

of what we have called the abnormal concentrations of precious metal, may seem enormous. But the reason is that on this map, for completeness' sake, even the faintest and most unworkable manifestations of the metal in question have been noted. In the case of gold this deception is carried further than in that of any other substance, by reason of the extreme interest with which gold has been everywhere looked for, and the facility with which under certain of its forms, those most anciently known and searched for, it has been recognized.

The truth is that the deposits of gold of a certain value are very exceptional, and that their volume only helps to increase the above mean percentage in a wholly insignificant degree. Let us, for instance, subtract the 93 miles length of the Californian lodes, which have yielded 280 millions, though of minimum width, the 31 miles length of the Rand mines, which will perhaps give 600 millions, with a practicable width of a few yards, Kalgoorlie, which will yield perhaps 80 millions, the Bendigo group, with equally narrow extent, which will give nearly as much, and a few famous deposits, the mean value of which may be estimated at 40 millions, in the present degree of approximation, like the Comstock lode, the district of Cripple Creek or the Yukon; let us further cut off the few piles of gold discovered in Columbia, Brazil, Guiana, Homestake in Dakota, Hungary, the Ural, on the Yenisei, the Lena, or the Amur;[1] and what

[1] Among the Siberian placers it is estimated that those of Djilinda and Djolon (Zeia in the Amur province) have each yielded 4 millions.

remains of the known and worked deposits in the rest of the globe will be small indeed. It is indeed the infinitesimal traces contained in all parts, if not universally, in the rocks, and almost always impossible to perceive even in analyses, so infinitesimal is their nature, which, multiplied by millions of cubic miles of rock, give the above result. This observation goes to support the point on which I have already insisted, namely, that below the present workable percentage there exist almost indefinite quantities of gold in the form of poorer and poorer ores, ores the utilization of which only depends on one question, that of cost price.

We gain a better idea of this by making a similar calculation for iron. In this case the mean percentage in the earth's crust, contrary to that at which we arrived empirically in the case of gold, is directly and chemically determined by numerous analyses, which were easier to conduct since this percentage is two million times greater. In the same 55,984,500 cubic miles which form the earth's crust to a depth of 5 furlongs, there are, at 4·70 per cent., 16,500 million million tons of iron, while the estimates relating to the deposits proper of iron known to-day hardly exceed 16,000 million tons, or more than a million times less. If just now, instead of starting for our calculation above from the total percentage of iron, we had started from this figure relating to the workable percentage, we should have obtained, instead of 1,240 million millions of gold to be extracted, only 1,240 millions, that is to say a far too small total,

under the same present conditions as have served as a basis of the calculations relating to iron, since it hardly represents the present output for fifteen years. But when we speak of 16,000 million tons as *known*, we are only considering deposits situated in industrially exploitable conditions, conditions far more rarely realized for iron than for gold, supposing an equal mineralogical knowledge of the deposits. This figure therefore is not in contradiction with the results obtained above, and we are once more led back by this path to suppose that human activity throws itself upon gold in a feverish haste which raises the gold output too high in proportion to the mean percentage in the earth.

CHAPTER II.

THE GEOGRAPHICAL DISTRIBUTION OF GOLD IN THE PAST AND THE PRESENT.

§ 1.—Gold in the past: antiquity and the Middle Ages—The discovery of America.
§ 2.—The first modern gold age—California and Australia.
§ 3.—The present gold age—The Transvaal, Western Australia, Colorado, Mexico, Alaska, etc.—The present distribution of gold production over continents and countries.
§ 4.—The origin and value of the world's stock of gold.

We have now seen the geological nature of deposits of gold. The conditions necessary for the production of such deposits on the surface of the earth are strictly localized, and I have insisted upon the really exceptional character of concentrations sufficient to allow of working on a large scale. The centres of gold production capable of taking a serious part in the world's supply are few even to-day, when in every country mining enterprises are animated by a feverish activity; they were still fewer in ancient times, when the knowledge of our globe was less advanced. Besides, one should not forget that each of the deposits successively discovered represents only a precarious and temporary source of wealth. Contrary to the idea which is too often held of a mine, a lode of gold, and *à fortiori* an alluvium, is not like a field which can produce a new harvest every year; we dip into it like a bag, and it is soon emptied. It would

therefore be quite insufficient to limit ourselves to the present, which after all is only a stage in the process of development, in order to arrive at the geographical distribution of gold over the earth; we must also turn our attention to history and utilize the teaching of the past. In this way alone shall we be able to understand the real manner in which gold has been distributed over the earth, to estimate the respective values of the various deposits, to compare the great continents in respect of their richness and the part they have taken in forming the world's stock of gold, and, finally, to arrive at some conclusions, which we shall need later on, concerning this very richness in gold and the probabilities of future production and distribution.

§ 1.—*Gold in the past—Antiquity and the Middle Ages—The discovery of America.*

The ancients knew a great many deposits of gold, of which almost the last traces have disappeared—an illustration of that natural law of exhaustion of which I have already made frequent mention. A day will, perhaps, even come in the near future when the Californians will be astonished on hearing that their ancestors gathered gold in their rivers, as might be the inhabitants of the Adour basin, the Malaga district, the plain of Granada, or the Po valley on reading that placer-workings once existed in their country. I do not pretend that any of the ancient alluvial deposits, even the Rhine gold itself or the gold of Pactolus, were equal in richness to California or the Transvaal, yet it does not seem right to depreciate unduly the

real value of the workings which furnished gold to antiquity, and here, as in many other cases, there has been perhaps too great a tendency to treat as nursery tales the accounts of Herodotus and the other ancient geographers. The glitter of gold in antiquity is neither confined to their glowing accounts nor wholly the product of their Southern imaginations. Numerous specimens of that antique gold have been discovered in the tombs of Egypt, Mycenæ, etc. We are forced to admit that the Mycenæan kings laid in their sepulchres with masses of gold, and the Egyptians, covered with golden jewels, necklaces, and breastplates, did not have buried with themselves all the precious metal which they possessed, and that by far the greater part must have been kept by the living. In another part of the world, we know what treasures of gold long accumulated were found by the Spaniards during their conquests in America, although De Humboldt's estimate[1] has reduced to 4 millions the treasures of Montezuma and the Incas; and it is impossible to forget the abundance of precious metals which has always existed in the Far East.

Even if we limit ourselves to the ancient world, to the regions of the Mediterranean which are now so poor in gold, because they were exhausted many ages ago, we can get an idea of the places where gold was worked from several perfectly definite historical references.[2]

[1] *Essai politique sur le royaume de la Nouvelle Espagne*, Vol. III. Cf. de Foville in *Annales de Géographie*, 15th May, 1897.

[2] The majority of these references will be found reproduced in Hugo Blümner's *Technologie und Terminologie der Gewerbe und Künste bei Griechen und Römern*, Leipzig, 1886. Vol. IV., p. 10.

The earliest centres of gold mining were evidently in the zone of the most ancient civilizations, in Armenia, Chaldæa, Asia Minor or Egypt. We have hardly any information on the mines which may have existed very early in Armenia, the Altai or Ural provinces, Siberia, etc., although a passage of Herodotus about the Arimaspians has been applied to the Ural province. But it is very probable that gold brought from there and from India in caravans helped to swell that treasure of the Persian kings which played so great a part in their dealings with Greece. Greece herself was very poor in gold till the Persian wars; but Persia certainly possessed large quantities. The Armenian deposits of gold are mentioned by Strabo; those of Colchis, west of the Caucasus, gave rise to the fabulous legends of that Golden Fleece, which was evidently a method of collecting gold dust in the water-courses. In Chaldæa, also, gold was present in lodes and sand.

The much better known mines of Asia Minor have long been famous, and it would not be impossible that some of them should again become so when these rich countries finally escape from the grasp of Turkey to enter once more into civilization. To get some idea of their wealth it is enough to think of the olden legends of Crœsus, king of Sardis, or Midas, king of Phrygia, who changed everything that he touched into gold. In the time of Herodotus, the ancients boasted of the immense quantity of gold works of art offered at Delphi by these "barbarians," first Midas, then Gyges, king of Lydia and ancestor

of Crœsus. There were manifestly several great mining centres in Asia Minor five centuries before Christ, which are known to us through Herodotus, and later through Strabo, though at the time of the latter geographer (the age of Tiberius) the mines in question were exhausted. Phrygia was rich in gold: Tantalus and the Pelopidæ, then Priam, drew their precious metal from the mines of Astyra (north of Troy), which, though formerly very rich, as the mass of detritus and the depth of the excavations showed, only yielded very insignificant products in the time of Strabo. Further south, in Lydia and elsewhere, in the plain of Sardis, the gold of a Gyges, an Alyattes, or a Crœsus came partly from the Pactolus, which must have been near Sart (Sardis), in one of the valleys descending from Mount Tmolus to the river Hermos. The sands of this river formerly contained many grains of gold, but there was no longer any trace of them in Strabo's time. Another centre of gold-working, where at the beginning of the Christian era remains of abandoned works were still to be seen near a little deserted town, lay more to the west, between Pergamum and Atarneus in the Troad, on a level with Mitylene. Finally Mount Sipylus, which is north of Smyrna, once furnished gold to Tantalus.

Continuing to pass up the Ægean Sea towards the north, we soon arrive at the mines of Macedonia and Thasos, equally celebrated in the very earliest times. Herodotus, who had visited them himself, describes the very important gold mines of Thasos in a district where to-day there are only complex lodes, chiefly

cupriferous, to be seen; but the greatest wealth of gold must have been on the mainland. The mines situated west of Philippi, in the range of Mount Pangæus, at Skaptè Hylè, at Datum, near the coast, at Asyla, near Crenides, and then, going up the Strymon (Strouma) the mines of Seres towards Melnik and the present Bulgarian frontier were celebrated in the fifth century before Christ; even Cadmus, on Strabo's authority, got all his gold from the mines of Thrace and Mount Pangæus. In the time of Strabo a waggon often turned up nuggets of gold there. Finally, Strabo mentions Mount Bermius in Macedonia, in the district of lakes Kastoria and Prespa, as having furnished gold to King Midas; this mountain, in his opinion, had been the original home of the Phrygians before their migration to Asia.[1] He also mentions the gold of Pieria, in Macedonia.

Among the islands of the Ægean Sea, excluding Thasos, of which I have already spoken, Cyprus has occasionally been mentioned as producing gold; but this, at any rate, was only a side issue in the working of copper. On the other hand, Siphnus was long celebrated for its gold mines, which enabled it to pay tribute to Athens: traces of shafts are still to be seen there, and Pausanias speaks of a tidal wave which interrupted the workings.

[1] This mountain produced 1,000 talents of gold, or four million pounds sterling, in the time of Philip of Macedon. The figure is enormous and must have been exaggerated by a species of optical delusion. However, it is not absurd, in view of the thousands of slaves which were then available, and the pureness of the gold ores which required no perfection of metallurgical treatment.

South of the Ægean Sea, Egypt must have been the principal source of Egyptian and Mycenæan gold. These mines of Egypt, which seem to have been very rich and on which efforts are being made to-day to start the breaking up of several lodes, were situated in the mountainous range between the Nile and the Red Sea, in the neighbourhood of the latter, especially at the two points of Um-Rus and Berenice (the latter being nearly as far up as the first cataract). The mines and their working are known from various references and papyri, notably from a long passage of Diodorus Siculus. We know positively that the kings of Babylon and Cappadocia sent there to get gold and that Ptolemy II. derived from the mines a large annual revenue, estimated, perhaps rather highly, at £4,000,000. At the beginning of the Christian era the mines, although failing, were reputed to produce from 3 to 3·20 millions.[1]

In the same way there existed gold mines in Arabia, in the neighbourhood of the Red Sea, and the interior of Africa furnished gold which was carried by caravans, not to mention the legendary Ophir, which may be taken to represent all the sea-borne cargoes entering the Mediterranean by the Red Sea.

After the period when the working of gold was principally confined to the eastern shores of the Mediterranean, another phase was seen when the region of productive mines changed to the west, into the countries of the wild Spanish, Gaulish or Italian Alpine tribes. Strabo and Pliny indicate to us, in

[1] L. de Launay, *Richesses minières de l'Afrique*, pp. 116—121.

these different parts, numerous deposits of gold, of which some were on the point of exhaustion even in their time. There are, for example, in Spain, the coast region of Malaga, and probably the slopes of the Sierra Nevada, in the territory of the Oretani, from Malaga to Cartagena, throughout what used to be called Bastetania (Andalusia), where numerous ores of all kinds, and even traces of gold, still exist.

A little further towards the west lies Turdetania, which corresponds to the districts of Huelva and Seville. Strabo describes with enthusiasm the gold mines of this district, and especially the auriferous sands, besides the iron and copper mines. We know that in this region the cupreous pyrites of iron, sometimes slightly auriferous, abound, and it is probable that the mechanical formation of these was instrumental in producing abundant auriferous sands in the alluvia. In Portugal (Lusitania) various watercourses north of the Tagus carried along grains of gold in great quantity. The Douro was auriferous, and, according to Pliny, who was nearly a contemporary of Strabo, Asturia, Galicia and Lusitania (Portugal) produced 20,000 pounds' weight of gold a year, which was obtained by some kind of hydraulic method. It is a district where auriferous sands are still known and also very numerous deposits of tin, a metal often associated with gold (notably in the Central Plateau of France).

In Gaul the gold mines of the Pyrenees and Cevennes were for a long time in repute. Pliny the Elder alludes to the mine of a certain Albicrates

there, the position of which is unknown. Strabo mentions in particular the country of the Tarbelli, which represents the west of the Basque country. "The Tarbelli," he says, "have in their territory the most important gold mines that there are in Gaul; for it is enough to sink shafts of insignificant depth to find plates of gold as thick as a man's fist, some of which hardly need to be refined. But in general the gold presents itself in the form of grains or nuggets." Likewise, Diodorus Siculus mentions the Tectosages; he speaks of the numerous mines in Gaul, where gold was abundant in all the temples and sacred places, though nobody thought of touching it. In the Central Plateau, at many points which in many cases still retain the name of L'Aurière, the trace of ancient detritus has been found where most probably auriferous sands must have been washed. Strabo and Tacitus mention the presence of gold in England. The Romans certainly seem to have worked some mines in Wales and auriferous sands in Devon and Cornwall.

Rome began, like Greece, by being very poor in gold, and a reference from Pliny has often been quoted to the effect that there was a difficulty in finding 1,000 pounds' weight of gold in the city to pay ransom to the Gauls. The Gauls, on the other hand, rich in gold from their mines and conquests, were accustomed to decorate themselves with it, even in battle. Rome had no gold mines till she expanded towards the Alps. There is mention in Pliny of the mines at Vercellæ (Vercelli) in Piedmont, the farmers

of which had not the right to employ more than 5,000 labourers in the working, a condition which illustrates their importance. All those rivers which flow into the Po, the Doria Riparia, the Stura, the Orco, the Doria Baltea, the Sesia and their affluents have, moreover, continued to bring down a little gold to this day. Strabo specially mentions as auriferous the country of the Salassi, towards the Val d'Aosta, where in his time the washing of the auriferous earths had been started which annoyed the agricultural tribes living down the river, and occasioned, as he says, frequent quarrels between the two tribes. This might well have come out of a modern description of California.

Again, in Carinthia and Friuli, north of Aquileia, gold dust and nuggets were found at a depth of a few feet. "The barbarians," says Strabo, "had at first taken Italians to assist them in their workings; but when they found out that in two months the value of gold all over Italy had decreased by one-third, they sent away these foreign partners, expecting thenceforth to reserve to themselves the monopoly of their mines. There, as in Spain, gold is not only extracted from the bowels of the earth, but is also drawn from the beds of rivers, which carry it down in the form of grains, though in less quantity than those of Spain."

The Romans also got gold from Dalmatia and, above all, from Transylvania, the value of which they had begun to recogniże. India had produced gold dust for ages; many centuries before Christ that far-off country was already spoken of where ants, so it

was asserted, brought up gold from under the earth. Probably the Urals, on one side, and Central Africa on the other, also sent a little by caravan. It has been thought possible to apply to the Urals a reference from Herodotus quoted above, where he mentions the one-eyed Arimaspians who extracted the gold of the mountains and sold it to the Agrippæi, a sacred tribe which had, it appears, the sole privilege of this commerce. Herodotus also mentions the exchanges for gold dust made by the Carthaginian sailors in Africa on the coast of Libya beyond the Pillars of Hercules.

Rome's wealth in gold increased more and more as she took possession of the world. There came a time when the precious metals abounded in the city, when gold was used to make massive statues and to gild the ceilings of rooms (to the indignation of old-fashioned citizens), and when Agrippina, the wife of Claudius, showed herself in public dressed in a tunic of plaited gold threads. Then came the barbarian invasions, and that gold, plundered and carried off at random, was scattered and disappeared. The working of the ancient mines ceased the more readily because the majority became exhausted, and for several centuries Europe was very poor in precious metals. Men were content at the most to go on scraping at a few old lodes. By the end of the Middle Ages it is estimated that not more than 12 to 16 million pounds' worth of gold remained in Europe.

Towards the 13th century a revival began, which reached its zenith at the time when the discovery of

the New World interrupted men's efforts, by bringing into circulation quantities of gold far larger than anything that Europe could produce. During that period there was a certain amount of active working in the Alps, the Tauern, Transylvania and various parts of Spain, and operations were begun on the mines of Germany, Norway, England (Wales), etc.

The great geographical discoveries at the end of the 15th and the beginning of the 16th centuries changed the conditions of mining. In 1519 Fernando Cortez entered Mexico. In 1527 Pizarro landed in Peru, From 1535 onwards Charles V. suspended the working of the Spanish mines to send the miners into the New World. Gold soon began to flow in from all these Eldorados, which were successively sought and discovered between the Isthmus of Panama and Brazil; and the wealth of Mexico, Guiana, Peru, and the treasure of Montezuma and of the Incas inflamed men's imaginations. At the same time Africa was sending gold dust, patiently accumulated by the inexpensive labour of the negroes, which arrived at the coast and kept up the legend of fabulous riches in the interior: there was gold from the Gold Coast, on the Gulf of Guinea, gold from the legendary Monomotapa (corresponding to a part of modern Rhodesia), where the Portuguese worked from the 16th century, gold from Madagascar, Egypt, India, etc. etc. Part of the figures escaped all supervision, but the principal item, which was furnished by the colonies of Spain and Portugal, was carefully watched by the avaricious governors, and it is on the figures preserved under

these heads in the archives that the tables of Michel Chevalier, Soetbeer, etc. have been based.

According to these approximate statistics, the world's mean annual production of gold rose progressively from 5·80 tons about 1500 to 7·16 about 1540 and 8·51 about 1560, round which figure it oscillated till 1660, or practically for a century. While America's output rose to 7·75 tons at the end of the 18th century, that of Africa fell from 3 tons to 2, and that of Europe from 2 tons to 1. In the 18th century gold production again took an upward step. New life was given to it by the output of Brazil and the more methodical and deeper working of a number of mines elsewhere. In 1700 the annual amount was over 10 tons and in 1760 over 24. Brazil alone started at 2·75 tons a year in 1701 and reached 8·85 in 1721—1740 and 14·60 in 1741—1760. But this was the culminating point. The revolt of the Spanish colonies gave the death blow to an industry which was already decaying. From the known deposits all that they could yield had been taken, while, in accordance with the general law on which I have already insisted, a new movement of geographical expansion had to be awaited before gold production could make a new start. Till that period it decreased continuously, as the following table (I. p. 94) shows: 17 tons in 1800, 11 in 1820, 14 about 1820—1830, and only another 20 in 1830—40.

About that time, apart from the continuous mining operations in Transylvania, the Ural province, Siberia and South America, and the gold dust of Africa, it

was still possible to make a living by prospecting along a good many European rivers; but it was Russia that was tending to head the gold output

TABLE I.—*The World's Production of Gold.*

Years.	Average Output.	Total.	Years.	Average Output.	Total.	Years.	Total
	Tons.	Tons.		Tons.	Tons.		Tons.
1493—1520	5·80	150·00	1848—1850	54·75	109·52	1890	178·80
1521—1544	7·16	171·84	1851—1855	199·38	996·94	1891	196·55
1545—1560	8·51	127·65	1856—1860	201·75	1,008·75	1892	220·63
1561—1580	6·84	136·80	1861—1865	185·05	925·28	1893	236·96
1581—1600	7·38	147·60	1866—1870	195·02	975·13	1894	272·57
1601—1620	8·52	170·40	1871—1875	173·90	869·52	1895	299·03
1621—1640	8·30	166·00	1876	156·01	156·01	1896	304·28
1641—1660	8·77	175·40	1877	171·72	171·72	1897	355·16
1661—1680	9·26	185·20	1878	179·17	199·17	1898	431·60
1681—1700	10·76	215·30	1879	163·65	163·65	1899	461·45
1701—1720	12·82	256·40	1880	160·13	160·13	1900	383·00
1721—1740	19·08	381·60	1881	154·99	154·99	1901	394·91
1741—1760	24·61	492·20	1882	153·45	153·45	1902	446·14
1761—1780	20·70	414·10	1883	143·51	143·51	1903	489·74
1781—1800	17·79	355·80	1884	153·04	153·04	1904	525·25
1801—1810	17·77	177·78	1885	163·13	163·13	1905	573·59
1811—1820	11·44	114·45	1886	159·72	159·72	1906	608·78
1821—1830	14·21	142·16	1887	159·13	159·13		
1831—1840	20·28	202·89	1888	172·00	172·00		
1841—1848	54·75	438·07	1889	185·78	185·78		
1493—1848		4,621·64	1849—1889		7,160·57	1890—1906	6,378·44
	Or 636 millions of pounds sterling.			Or 984 millions of pounds sterling.		Or 880 millions of pounds sterling.	

Total 1493—1907: 18,160·65 tons or 2,500 millions of pounds sterling.

instead of America, producing 3·30 tons towards 1825, 7 from 1831 to 1840, and 22·50 from 1841 to 1850. The above figures show how, owing to this new factor, the curve, which had reached its lowest

point between 1810 and 1820, had begun to rise, 30 years before the discoveries of 1848—1850, through finds in Russia and Siberia, which were new countries and difficult of access.

To sum up, it is estimated that from 1492 to 1848, between the discovery of America and that of the Californian alluvia, the production of gold rose to 636 millions or 4,621 tons, of which 80 millions came from America, 100 millions from Africa, 44 millions from Russia and Siberia and 20 millions from Europe. It is unnecessary to state that these figures are only approximate.

§ 2. *The first modern gold age—California and Australia.*

Two principal periods of gold production on a large scale are recognized in our own times, and they are separated by a phase of relative stagnation. The first corresponds to the almost simultaneous discovery of gold in California and Australia; the second began with the marvellous finds in the Transvaal, followed almost immediately by finds in West Australia, Colorado, Alaska, etc., and with the invention of new metallurgical processes (cyaniding, etc.), which caused a parallel revival in the older gold-producing countries, as if they had been bitten by a spirit of rivalry.

Between these two periods there was not, properly speaking, any cessation of that geographical and economic expansion which always causes as a direct consequence a revival of gold production. But it was not so much that attention was turned to entirely new

countries, as that territories already superficially known were finally brought into operation in the United States, East Australia, etc. In accordance with a law on which I have many times insisted, this period of more complete economic development is always much less favourable to the discovery of gold, which is almost invariably consequent on entry into a new country, than to the discovery of silver, then copper, and finally lead, zinc, iron, etc. In proportion as a country becomes populated and creates for itself easy means of communication, enterprise turns to less and less exalted metals, which their small value would at first have rendered unworkable and which come in to compensate the continuous exhaustion of the nobler metals, on which the first rush was made. As in the mythical history of humanity, which was determined in part by the same principle, we pass again from the age of gold to the age of bronze, and so on finally to the age of iron.

The successive stages by which possession is taken of a new piece of country recur almost always in the same order. At first the country is impassable, separated from civilization by a desert like the Witwatersrand or Western Australia, frozen like the Yukon, Cape Nome or Transbaikalia, malarious like the interior of Guiana, or simply without means of communication like British Columbia and Korea. Then a time comes when a few isolated individuals enter it, adventurers whom a lucky find has enabled to pick up a little gold dust in the river sands or in the outcrop of a lode. Others at once follow on their

heels: it is a time of intense, feverish development, of large individual production, of random digging and scrambled searching—a "rush," as it is called. Then the first alluvia, or, if it is lodes that they have found, the rich portions at their top, are exhausted,[1] and more scientific methods, capital, etc., are required in order to continue. Meanwhile, the country begins to change, grows civilized and, in many cases, becomes agricultural; then the prospectors, for whom there is no place, push on further, and for a thousand who fail or die, there are a few who succeed in making a fresh find. During this period, in the first mining centre which is evolved, the yield decreases a little, rises again, and finally comes down with a run when in course of time the deep parts of the lode are attacked with their complex ores which require a more delicate and costly treatment. At this stage mines have often ceased working and been abandoned, but to-day, when metallurgical processes are better and more widely known, this critical period is more easily overcome. This development, however, necessitates fresh calls for funds, a reorganization of capital, and, as a rule, can only be accomplished when means of communication have been made. The railways which are intended to serve several great mining centres lead to the discovery of others and at the same time make

[1] This law of the rapid exhaustion of auriferous alluvia, which has lately been illustrated in the Yukon, was formerly very marked in California. So also in Siberia, the district of Yeniseisk was from 1840 to 1847 the greatest gold producing country in the whole world. In 1847 it produced alone 20 tons of gold. The production decreased from year to year through the exhaustion of the alluvia, and the yield to-day is only 2½ tons. It is declining now after having produced 440 tons of gold, worth about £52,000,000.

their working possible. A period of quiet and continuous growth now succeeds the sudden shocks and changes of the beginning, and lasts for a greater or less number of years, till the time when the gradual increase in the depth of the workings causes a new interruption, an interruption, however, which can never be characterized as permanent, since the process in the technical side of mining and metallurgy, not to speak of the fresh demands for the metal which may begin to grow scarce, will, as a rule, cause the re-opening with more or less success of all the well-known older mines.

These stages are passed through more rapidly in proportion as Anglo-Saxon methods are employed, which aim at a quick return for capital without thought for the future. The desire to cover the cost quickly and to pay immediate dividends leads to the neglect of all but the "paying" ore of the moment and to the irremediable loss later on of reserves of poorer ores which would have proved a resource in years to come. To-day the normal life of a gold-bearing district is from 15 to 20 years, and 50 years is practically a maximum. We shall see this more clearly if we survey rapidly the history of the great discoveries of gold.

Amongst those which marked the middle of the nineteenth century the earliest and also the most sensational was the find in California in 1848. It contributed, not only by the amount of gold produced, but also by the gold-digging fever which it caused in every part of the world, to bring in the first of the two

modern "gold ages" which lasted till about 1875. In February, 1848, when California was ceded by Mexico to the United States, the country did not contain more than 10,000 inhabitants; the discovery of the first nuggets took place in March: from the month of May everybody was on the placers. At the end of the year there were already 6,000 gold seekers; there were 20,000 in 1849. In 1850 California was raised to the position of a State, and the gold fever raged for four or five years with an intensity which has remained historical. But after 1853 the inevitable exhaustion of the placers made itself felt and the era of the great hydraulic workings began.

It was then that the isolated miners, who were on the search for adventures, having no longer any place in an industrialized country, set out eastwards for new Eldorados to lands unknown but rich in hopes. These circumstances led to the discovery of the famous Comstock in Nevada, which was first looked on as a lode of gold and, after having been worked principally for silver, has again become in its old age a gold deposit. In June, 1859, two Irish miners, who were fated to die, one mad and the other in hospital, found this marvellous deposit in the Washoe district. Its great reputation began in 1861, when the stage of serious working and deep mining had been reached. In all, nearly 100 millions of gold and silver were taken from it. The fame of Comstock for a moment diverted the flow of miners in that direction; but the living tide was soon to pass beyond it to reach other new mines, gathering speed and strength in its onset,

and the crowd of diggers, like an army of gamblers, their passions roused by the attraction of the game, grew with every rumour of a newly-made fortune. In 1864, Eureka was discovered in the State of Nevada, which in 15 or 20 years produced more than 12 millions of gold and silver, of which one-third was gold. Thence, following the parallel corresponding to our transcontinental parallel, the flood passed into Utah (though for a time withstood by the Mormons) and Colorado, where Leadville was founded in 1874. At the same time streams began to flow towards the north in the direction of Montana and Dakota, and into Arizona on the south. Butte City, in Montana, dates from 1876, but the working of gold in lodes only began there in 1880. The flow went on, and prospectors turned off either to the north towards the Dominion, British Columbia and Alaska (Treadwell, in Alaska, dates from 1891, the Yukon from 1896, Cape Nome from 1899), or to the south towards Mexico, where the gold industry arose after 1894.

This last date, as we see, coincided with and came within the second gold age, which was chiefly due to the discovery of gold in the Transvaal. But before we come to that, we must go back to the other great continent of Australia which, with California, caused the gold movement of 1850. In Australia a little gold had been found in 1814 and 1839, but it was only in consequence of the excitement in California that in 1851 really important quantities of gold were found in New South Wales, and then at Ballarat in Victoria. The rush which occurred at the time

towards these parts invaded the Northern Territory after 1869. It began to spread to New Zealand from 1861 onwards, becoming especially marked after 1870, and to West Australia in 1893. As for the earliest gold fields, such as Ballarat and Bendigo, they still continue to produce a considerable amount, but at ever-increasing depths, which now exceed 3,600 feet, and with poorer and poorer ores for which very economical methods of extraction have been devised.

Finally, another great gold-producing country in the nineteenth century, where the discoveries for several reasons caused less sensation, though they nevertheless were an important factor in modern gold-production, was the Russian Empire. There, though in a less striking form, the phenomenon was the same: an advance towards the little-known east of Siberia, and after the exhaustion of the most westerly and accessible districts of the Ural, Ob and Yenisei the development of the Lena district, Transbaikalia, Manchuria and Korea. Towards 1850 the Russian Empire produced 22½ tons of gold a year. After 1870 the amount exceeded 30 tons; in 1888 it produced 35 tons, in 1895 it rose to nearly 48 tons, and then began to recede continuously.

It is principally these three countries—Australia and North America with a nearly equal output, and Russia with an output less by nearly a half—which produced almost all the gold from 1850 to 1888. Owing to so many simultaneous discoveries the production of this metal took a sudden rise from 1851 to 1860. It was the time when economists were afraid that there would

be too much gold, when prices rose in consequence of over-production, and prudent bankers jealously hoarded their white metal for fear of a serious diminution in the value of gold. In fact, the world's gold production was over 200 tons, or £26,800,000, but after 1861 this fine total began to decrease; it descended to 185 tons in 1865, 174 in 1875, and it stood at 144 in 1883, when it began to rise again by one of those periodical swings of the pendulum which characterize all phenomena of that kind.

§ 3. *The present gold age — The Transvaal, West Australia, Colorado, Mexico, Alaska, etc.—The present distribution of gold-production over continents and countries.*

THE PRESENT GOLD AGE.—We live in a gold age. This has been repeated for the last twenty years, and so convincing are statistics on this head that we must needs believe it. But let us remark at once that a gold age, an age of large gold production, is not necessarily a happy age; on the contrary, it must correspond, if no circumstance intervenes, with a diminution in the value of gold, a rise in prices and general distress.

This gold age has not been merely a lucky result of chance which caused the presence of precious metal to be recognized in the auriferous conglomerate of the Rand and brought into circulation from this source an annual quantity of gold, to-day over 24 millions. At the same time as the Transvaal was discovered, other rich deposits were found in other parts of the

earth, and the production, which was increasing in one direction, rose also in several others. Just as in 1848, the lucky finds were almost simultaneous and coincided with a reopening of older and apparently exhausted groups. For this there are two principal causes.

The first cause—chiefly of a political nature—was the colonial movement and imperialistic expansion which took place after 1880, and brought about with such rapidity the penetration of the black continent. This feat, which strikes us less because we have no vantage point of time from which to judge it, is as extraordinary as the conquest of Mexico and Peru in the sixteenth century. From the moment when civilization came into touch with these vast and almost untrodden regions, some discoveries of gold could not fail to be made, of which the most remarkable up to now has been that of the Rand, though others more remarkable may occur in the future. These discoveries were not made in those parts of Africa which had a long and proverbial reputation for containing gold, which had been known for centuries to send their gold down to the coasts and towards which there might have been a tendency to rush. The gold of Africa came neither from the Gold Coast nor the famous country of Kong, where it was said that the negro kings used to sit on a throne of solid gold, nor from Madagascar, which had exported gold for so long, nor from Monomotapa, where one sees on all sides the remains of works and the ruins of towns once erected for purposes of gold-digging. This might easily have been foreseen on

reflection. These countries could no longer produce gold without difficulty for the same very simple and evident reason which caused the European gold-working to disappear, that in a mineral deposit—though there is a tendency to imagine the opposite—what has been taken away no longer remains and that the accessible parts of these deposits had long been exhausted. It is possible that at a later day gold will come, and it has even begun to come, from these apparently exhausted countries, but only through the utilization of poor ores, which were formerly impossible to utilize, by means of perfected processes and deep mines. Meanwhile the gold of Africa has been given to us almost entirely by one deposit, the Witwatersrand, which at first sight had nothing very attractive about it; it was not accompanied by great auriferous alluvia; neither dust, nuggets nor specimens of fine crystals were seen, but only an ore with no brilliance and apparently no gold and very poor on the average, from which gold could only be extracted by an industry seriously undertaken on a large scale.

At the same time as Africa was giving us that colossal pile of gold (between 600 and 800 millions), a parallel expansion in Australia led to another great discovery of a similar kind, that of Kalgoorlie in West Australia, while both in North America and Siberia the continuation of the advance towards unexplored countries brought enough important finds practically to maintain, and in the former case slightly to increase, the rate of extraction, in spite of the exhaustion of older fields.

But these rapid strides in geographical exploration are not the only cause of our present age of gold; there is another of a technological or metallurgical nature, namely, the considerable progress made in chemistry and the facilities acquired for treating ores till now considered refractory. In fact, if we consider the greatest present gold-producing regions, the Transvaal, Kalgoorlie in West Australia, and Cripple Creek in Colorado, we see that in no case would profitable working have been possible thirty years ago. On the Rand the invention of cyaniding was necessary, a method practically applied there for the first time. In the two other cases tellurides, a hitherto unused form of ore, had to be dealt with. The fact is that, when we come to speak of the metallurgy of gold, we shall see that it has passed historically through three principal stages. There was first the early stage when free gold was extracted either mechanically or by an elementary process of fusion. Then came the period of amalgamation, the end of which we are now witnessing, when the greater part of the gold was extracted by means of its affinity for mercury. As the great industrial discoveries are always in some way provoked by the felt need for them, this method of amalgamation very soon followed the discovery of mines in the New World, where there was at once opportunity of applying it. Finally, the methods of cyaniding with or without preliminary roasting or of roasting and chlorinating, which are applied in Johannesburg, Kalgoorlie and Cripple Creek, only came into current

practice on a large scale with the discoveries of gold in these three districts.

Having made these general observations, we will try to estimate from statistics the present distribution of gold production over countries and continents, in order, by taking the past also into account, to arrive at the distribution of gold—a geological phenomenon—between these same geographical regions. We shall admit as provisionally and approximately correct the figures given by official statistics, the value of which will be discussed later on.[1] In most cases these figures, which often represent a minimum, are sufficiently exact for the very general observations which are now to be made. It must, however, not be forgotten that the exploration of our globe is very far from completion. In unexplored regions there is always the possibility of an extraordinary discovery which will upset in a moment the hierachy of the older gold fields as established by history. Thus, in 1887 the existence of the abnormal quantity of gold on the Rand was unknown, yet it is the largest that has ever been found at a single place, and may represent from 600 to 800 millions of gold to be extracted from about 40 square miles, of which 168 millions have already been extracted. In 1891 Cripple Creek in Colorado, which has already yielded 32 millions and will no doubt yield at least as much again, was not known. In 1895 the Yukon was not dreamt of, yet it has already produced more than 20 millions and will produce perhaps 12 or 16 millions more. It is,

[1] *V.* p. 157.

therefore, necessary to make large allowances for the unknown in our calculations, especially when they relate to almost unexplored regions.

If we first examine in round numbers the present gold production of the world, we see, as we have already seen, the rapid strides this production has made in the last 20 years. In 1882 the world produced 20·48 millions, in 1894 37·12, in 1901 54·36, in 1893 67·44, in 1904 71·88, in 1905 78·12, and in 1906 84. Table II.[1] shows the approximate distribution in recent years.[2] In this total of 84 millions I have already pointed out the place occupied by the three great gold-producing countries, the Transvaal (with which Rhodesia may be included), the United States and Australasia, which by themselves supply more than three-quarters of the world's total (64 out of 84 millions). When the production of these three countries is shown in the form of curves (*v.* Fig. 1, p. 108), they seem to follow one another and to get closer and closer every year, like riders in a furious race. The similarity of this development would have been still more striking, but for that very reason would have caused confusion, if their representative curves had been superimposed instead of being artificially isolated, for from 1893 onwards their production has been very much the same, now one, now another taking the lead. For a moment the South African war arrested the

[1] *V.* p. 108.

[2] I have already given in my *Statistique des gîtes metallifères*, p. 163, a similar table for 1888—1893. For detailed description of all the deposits mentioned later on I can only refer to my *Traité des gîtes metallifères* (Baudry, 1893) and my works *Les Mines d'or du Transvaal* and *Les Richesses minières de l'Afrique*.

competitor who at the time held the first place, but only for a moment, for in 1905 the Transvaal regained the upper hand, and its enormous superiority was accentuated in 1906, when it produced 24·76 millions against 20·20 in the United States and 17·24 in Australia. This supremacy of the Transvaal is destined to increase, and it is the more remarkable because it is hardly accurate to compare entire continents like Australia and the United States, which contain many different mining districts, with a small country like the Transvaal, or rather with a single localized centre of production like the Rand, which, though only 31 miles long, supplies practically all the gold of South Africa. In view of this consideration, the wealth of this mining centre, which by itself rivals and excels all the others, appears still more surprising. So also in point of accuracy the division of South America into several republics tends to obscure its importance and falsify its relation to North America. If we group all South America together, we find that it produced in 1903 2·84 millions against 15·28 in the United States, and in 1905 2·32 against 18·32. We shall get more exactitude in these data when we survey the different countries one after the other. But first let us bring into greater prominence the superiority of a few great mining centres, which come immediately after the Rand in importance.

While the Rand to-day produces about 24·80 millions, the district of Kalgoorlie in West Australia touched its highest point in 1903 at 4·28 millions and then fell. The district of Cripple Creek in Colorado

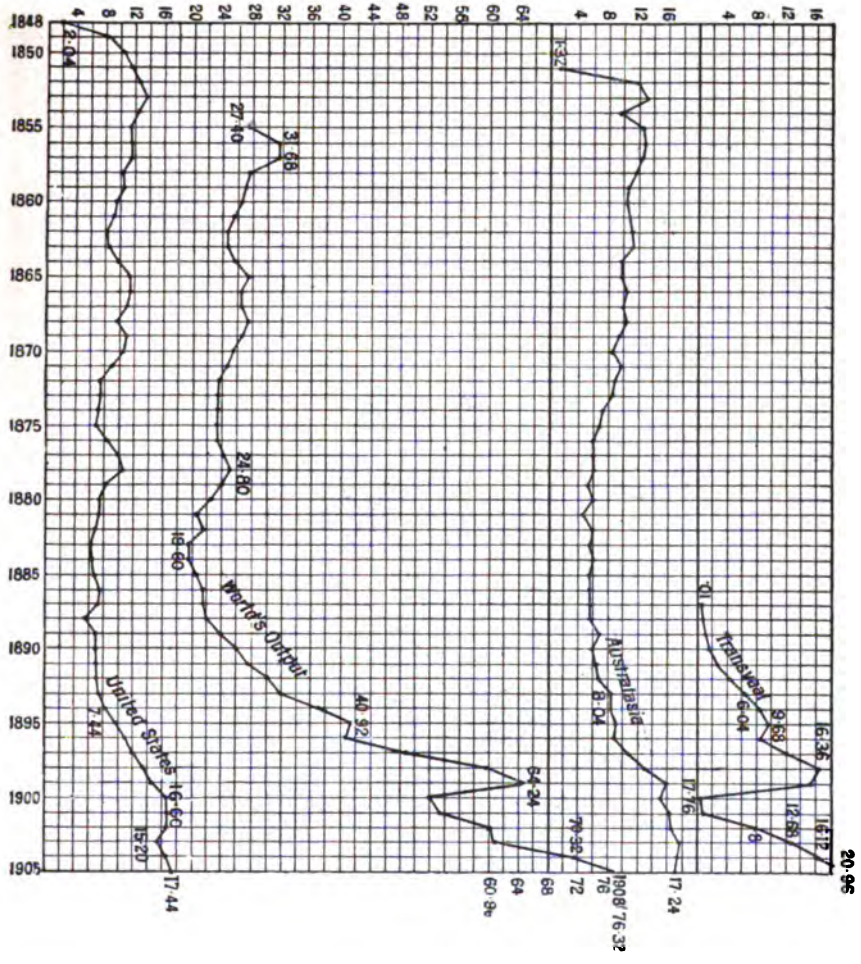

FIG. 1.—PRODUCTION OF GOLD IN THE THREE PRINCIPAL COUNTRIES, THE TRANSVAAL, UNITED STATES, AUSTRALIA, AND THE WHOLE WORLD.

touched 3·32 millions in 1904, of which ·54 came from the Portland mine alone. The Yukon produced 2·10 millions in 1904, after having reached 3·60 in 1900. The district of Cape Nome on the Behring Sea has yielded about 1·04 millions a year for the last few years. The Homestake mine in Dakota produces 1·04 millions a year, and Golden Reward close to it ·24 million. The Treadwell mine in Alaska produced ·62 in 1904; the Waihi mine in New Zealand ·60 in 1904; French Guiana ·48 to ·60; the El Oro mine in Mexico ·48; Mount Morgan in Queensland ·40; the Butte City district in Montana ·28; and the Gold Coast of Africa touched ·84 in 1906. To go further into detail and compare one mine with another would be useless considering the purely general and theoretic nature of the ideas which claim our attention at this moment, since one district, such as the Rand, has been parcelled out into numerous concessions, which are like so many separate entities, while in another district the work has more wisely remained under the control of one single authority.

THE PRESENT DISTRIBUTION OF GOLD PRODUCTION OVER CONTINENTS AND COUNTRIES.

1. *Africa.*—In Africa the principal centre of gold production, which is also the first in the world, is the Witwatersrand, or Rand, near Johannesburg, discovered only in 1887. The natural development of the industry in this part was thrown back for more than five years by a fatal war lasting two and a half years. From August, 1899, to May, 1905, nothing

more was done than to repair the damages caused by the British annexation and return to roughly the same rate of production as before. It is as if the district had become five years younger. In spite of this, there exists an industry here to-day which with more than 9,000 stamps and 143,000 men (80,000 black, 46,000 Chinese and 17,000 white) crushed in 1905 about 10 million tons of ore producing 20·8 millions of gold and in 1906 24·58 millions. With the other districts of the Transvaal added the total is brought to 24·76, and with Rhodesia to 26·88 millions. In view of the daily progress in technology and the opening of every known mine which may be predicted as soon as there is no longer shortage of labour, we have a right to expect before long an annual production of 32 millions.[1]

Beside these figures all the other gold-bearing districts of Africa look foolish. Some, however, have played an important part in history. Without mentioning the Egyptian mines, which must have supplied a large part of the gold used in antiquity,[2] it is certain that the West African Gold Coast exported for several centuries quantities of alluvial gold impossible to estimate, but probably over 80 millions. The numerous

[1] In the course of 1906 the crushing capacity was increased by 1,345 stamps. The number of labourers in the Transvaal (gold and coal mines) was increased by 5,000 Kaffirs and 5,900 Chinese with 600 less white men, and finally in December, 1906, stood at 117,000 blacks, of which 80,000 worked in the gold mines, 53,000 Chinese and 19,000 whites. The ore extracted increased by 320,000 tons; 414 new drills were set working. In a very short time 3,000 more stamps could be put into operation. It must be added that the latest deep soundings have demonstrated the continuance at a depth of the percentage of gold, and even, locally, its increase.

[2] See above, p. 87.

TABLE III.—Annual Gold Output in Tons and Pounds Sterling of the Three Present Chief Gold-producing Countries since the First Discoveries.

Years.	United States.		Australasia.		Transvaal.		World's output.		Years.
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	
1848	15·14	2,070,565	—	—	—	—	54·75.	7,538,838	1848
1849	60·57	8,278,844	—	—	—	—	—	—	1849
1850	75·69	10,745,582	—	—	—	—	—	—	1850
1851	83·28	11,383,393	11·11	1,326,594	—	—	199·38	27,435,788	1851
1852	90·85	12,418,198	96·73	11,866,768	—	—	—	—	1852
1853	98·42	13,453,139	102·55	12,821,884	—	—	—	—	1853
1854	90·85	12,418,198	76·52	9,323,197	—	—	—	—	1854
1855	83·28	11,383,393	93·16	12,092,482	—	—	201·75	27,782,400	1855
1856	83·28	11,383,393	100·88	12,557,344	—	—	—	—	1856
1857	83·28	11,383,393	93·97	12,096,507	—	—	—	—	1857
1858	75·71	10,348,589	90·23	11,599,824	—	—	—	—	1858
1859	75·71	10,348,589	83·65	10,736,890	—	—	—	—	1859
1860	69·65	9,520,582	81·39	10,431,628	—	—	201·72	27,781,996	1860
1861	65·11	8,899,781	83·95	10,752,744	—	—	185·03	25,483,320	1861
1862	59·35	8,113,188	86·65	11,035,399	—	—	—	—	1862
1863	60·57	8,278,844	86·89	11,062,732	—	—	—	—	1863
1864	69·65	9,520,582	76·10	9,700,071	—	—	—	—	1864
1865	80·59	11,015,585	78·08	9,953,927	—	—	—	—	1865
1866	81·01	11,072,993	80·14	10,201,342	—	—	194·99	26,856,020	1866
1867	78·32	10,705,597	76·68	9,812,902	—	—	—	—	1867
1868	72·68	9,934,585	80·33	10,293,129	—	—	—	—	1868
1869	77·98	10,659,126	75·09	9,564,756	—	—	—	—	1869
1870	75·71	10.348,452	65·14	8,351,620	—	—	—	—	1870
1871	65·88	9,004,884	75·65	9,610,040	—	—	173·88	23,947,554	1871
1872	54·51	7,450,973	68·88	8,781,060	—	—	—	—	1872
1873	54·51	7,450,973	63·62	8,123,978	—	—	144·72	19,932,640	1873
1874	50·72	6,933,503	54·76	7,019,316	—	—	136·53	18,803,400	1874
1875	50·57	6,913,264	52·06	6,652,683	—	—	146·68	20,202,000	1875
1876	60·41	8,258,004	45·92	5,860,521	—	—	156·01	21,486,640	1876
1877	71·01	9,706,876	46·00	5,880,000	—	—	171·72	23,609,859	1877
1878	77·52	10,595,972	47·80	5,956,654	—	—	179·17	24,676,028	1878
1879	58·90	8,050,452	48·21	4,937,440	—	—	163·65	22,538,967	1879
1880	54·16	7,448,000	43·28	5,640,000	—	—	160·13	22,053,704	1880
1881	52·21	7,189,840	39·08	4,691,880	—	—	154·99	21,346,386	1881
1882	48·90	6,734,000	43·75	5,648,440	—	—	153·45	21,133,695	1882
1883	45·14	6,216,000	44·06	5,564,040	—	—	143·51	19,765,222	1883
1884	46·20	6,380,000	46·22	5,802,480	—	—	153·04	20,678,373	1884
1885	47·70	6,589,160	44·57	5,578,720	—	—	163·13	22,467,856	1885
1886	52·66	7,210,000	42·91	5,425,480	—	—	159·72	21,997,160	1886
1887	49·17	6,837,600	44·93	5,520,000	1·35	15,200	159·13	21,916,559	1887
1888	49·91	5,521,560	44·56	5,521,560	7·17	841,200	172·00	22,832,797	1888
1889	49·35	6,756,800	53·75	6,562,200	11·78	1,364,480	185·78	25,586,962	1889
1890	49·41	6 805,480	48·87	5,971,680	15·39	1,723,920	176·80	24,625,444	1890
1891	49·91	6,873,880	50·83	6,235,680	22·67	2,774,240	196·55	27,070,680	1891
1892	49·65	6,837,600	55·43	6,781,840	39·44	4,584,920	220·63	30,386,190	1892
1893	54·08	7,448,840	58·36	8,041,600	44·09	6,072,160	236·96	32,632,922	1893
1894	59·43	8,188,540	59·95	8,259,920	60·71	8,364,480	272·57	37,139,584	1894
1895	70·13	9,662,600	64·54	8,892,880	70·52	9,716,200	299·03	41,183.817	1895
1896	79·88	11,005,680	64·92	8,945,640	62·99	8,639,520	304·28	41,906,531	1896
1897	86·30	11,890,200	78·21	10,776,240	85·32	11,756,280	355·16	48,914,470	1897
1898	96·99	13,363,720	93·00	12,813,600	118·97	16,391,560	431·60	59,441,473	1898
1899	106·91	14,729,960	113·88	15,690,520	111·49	15,532,840	461·45	63,553,233	1899
1900	119·53	16,441,960	108·77	14,986,880	2·97	410,320	383·00	52,748,209	1900
1901	120·69	16,627,600	115·94	16,083,040	7·43	1,025,880	394·91	54,388,528	1901
1902	120·35	16,582,520	121·47	16,736,120	58·05	7,997,600	446·14	61,445,711	1902
1903	110·72	15,192,160	134·24	18,412,400	92·16	12,644,880	489·74	67,449,235	1903
1904	121·40	16,662,000	131·28	18,006,400	117·50	16,124,000	525·25	71,916,488	1904
1905	132·50	18,152,400	129·30	17,744,000	152·30	20,932,000	573·59	78,142,392	1905
1906	153·10	20,208,000	126·60	17,232,000	187·50	24,760,000	608·78	84,000,000	1906
Total	4,327·31	591,645,702	4,124·56	535,968,087	1,269·85	171,671,680	13,164·34	1,832,267,819	Total

N.B.—From 1850 to 1872 the world's output has been calculated for periods of five years upon the estimates of Dr. Adolph Soetbeer. From 1873 the figures are those of the Director of the Mint Bureau of the Treasury at Washington.

attempts made for ten years to work the primitive deposits, the original source of the West African placers, have furnished a new proof, after many others, of the illusion of imagining that with perfected industrial methods brilliant results must necessarily be obtained from deposits of gold which have been worked for centuries by the natives. However, after a good deal of fuss and many failures, West Africa succeeded in producing ·84 million in 1906.

Another gold-bearing centre in Africa, concerning which imagination has also been given free play, is the French colony of Madagascar, which seems at last to be getting over the difficulties caused by too great enthusiasm at the start. The output, which was ·14 million in 1900, rose to ·23 in 1903, and ·25 in 1906. Finally, on looking into the future, we must without question bring in the vast expanses of Central Africa which have an abundance of iron and copper ore produced by oxidations of pyrite, and it would be very surprising if some fine gold ores were not one day found among them.

2. *America.*—The western side of America from one extremity to the other, from Behring Strait to Tierra del Fuego, in that region of recent plications and eruptions which gives to the Pacific Ocean its curves, presents the most remarkably metallized tract, and the richest in precious metals, in the world. The relative importance of the north and south continents has not always been the same. South America, after having been for three centuries the source of gold as well as silver, first with Peru, Chili and the Guianas,

and then Brazil in the eighteenth century, has only had a very restricted importance in the nineteenth century, while that of the United States and afterwards of Canada has gone up, as is well known, with a bound. But perhaps equilibrium is once more to be established and the other end of the scale to go up again when the republics of South America, under pressure from North America, adopt a course of general development of which Mexico has given them an example. South America has remained, as Mexico did for some time, at that critical stage in the life of gold and silver mines when it is necessary, after having treated with ease the rich ores on the surface, to expend much more trouble on working the poorer ore of the depths. When this new stage has been resolutely entered upon, we may hope for a good recovery in the South American mines.

If we pass quickly along the west side from north to south of the American continent (Fig. 2, p. 114), we find first in the extreme north, on the Behring Sea Cape Nome, an alluvial deposit very famous at this time, because its discovery only dates from the end of 1898, but which cannot fail to have only a short industrial existence—a truth which will have to be repeated in the case of all alluvial deposits. At Cape Nome the alluvia of the littoral were used up in three years, and to-day the frozen alluvia of the inland placers are being worked, yielding about 1·04 millions a year. The mining centre of importance nearest to Cape Nome is some 687 miles away in the Dominion, though on the frontier of Alaska, near Dawson City,

on the Yukon (Klondyke, *vide* Fig. 2). The wealth of the Yukon placers, which seemed fabulous at the moment, has only been a meteoric burst, as might easily have been foreseen. This deposit, discovered in 1896, is already well on the way to exhaustion, at least so far as concerns the alluvia, from which alone up till now have results been obtained. After reaching 3·6 millions in 1900, the output fell to 2·36 in 1903 and 2·10 in 1904. However, 20 to 22 millions in all have come from there, of which 12 millions came from Bonanza and Eldorado Creeks alone, which are now exhausted. But this figure, high as it appears, only represents one year's mining on the Rand, and it is perhaps a liberal estimate to value the quantity of utilizable gold which can be extracted on the Yukon within a limited time at 40 millions, in spite of the workings on a large scale which are on the point of being organized, and the new stage which is about to be entered.

From here it is necessary to take a leap of 437 miles to come to the famous Treadwell deposit in Douglas Island, off the coast of Alaska, which was discovered in 1881, and where considerable masses of exceedingly poor ore are vigorously worked with 540 stamps. These ores are, perhaps, the poorest of the kind in the world, averaging 7*s.* 6*d.* to 9*s.* 3*d.* a ton; 500,000 to 600,000 tons are crushed in a year, and the yield in 1904 was ·62 million.

The prosperous part of British Columbia is 875 miles further south, towards the frontier of the United States, in the two centres of Boundary and Rossland.

FIG. 2.—MAP OF THE DISTRICTS YIELDING GOLD IN WESTERN NORTH AMERICA.

Its gold output, though of recent date, rose in 1904 to 1·30 millions. These westerly districts of the Yukon and British Columbia are not the only gold-bearing regions in Canada. Mention must also be made of Nova Scotia, in the opposite extremity of the country, where gold was discovered in 1891, and in 1892 nearly three-quarters of a ton was produced. But let us return to the west. Another 625 miles, and we reach the country of California, without question one of the richest and most extensive gold fields in the world. The famous Mother Lode, east of San Francisco, is 75 miles long, and is continued by other lodes running parallel towards the north. The Californian gold field, discovered in 1848, yielded nearly 4 millions of gold in 1905. Possibly in the next ten years it may produce nearly 280 millions. However, the decrease has been very marked since the great activity of 1853—1891. In 1848 the output was 1·68 millions, 13·44 in 1853, 9·32 in 1860, 4·56 in 1868, 3·64 in 1880, 2·52 in 1891, 3·95 in 1905. In 1860, when California yielded 9·32 millions, all the other States only contributed ·20 million. In 1868 the proportion was 4·56 to 5·36, in 1878 3·17 to 6·62, in 1905 3·95 to 14·20. By 1860 all the recent alluvia, and the older placers to a great extent, were exhausted. From that point the growing activity in lode working caused a continuous recovery, from 3·49 millions in 1902 to 3·95 in 1905. To-day the workings are 1,950 feet in depth. Thus California, which exhibits the most considerable total and the most continuous working, holds at the

end of sixty years, if not a pre-eminence in the output of the United States, at least an honourable second place. Up to now it is in this district, together with the province of Victoria in Australia and the Rand, where deposits of gold have been seen to succeed one another with the greatest regularity at considerable depths (3,900 feet in the Bendigo group in Australia,

TABLE IV. DISTRIBUTION OF GOLD PRODUCTION IN THE UNITED STATES.
(*In Millions of Pounds.*)

The States are ranged in order of their present importance.

States.	1878.	1890.	1900.	1901.	1902.	1903.	1905.	
	Millions.	Millions.	Millions.	Millions.	Millions.	Millions.	Millions.	Tons.
Colorado	·69	·86	5·99	5·75	5·91	4·68	5·27	38·48
California	3·17	2·60	3·29	3·51	3·49	3·34	3·95	29·02
Alaska	—	·15	1·69	1·43	1·73	1·79	3·02	22·04
South Dakota ...	·62	·66	1·28	1·34	1·30	1·41	1·43	10·45
Montana	·46	·68	·97	·98	·90	·90	1·04	7·61
Nevada	4·06	·58	·41	·61	·60	·70	·97	7·07
Utah...	·08	·14	·82	·76	·74	·76	·96	6·99
Arizona	·10	·20	·86	·84	·83	·89	·72	5·26
Oregon	·23	·37	—	—	—	—	·27	1·98
Idaho	·23	·37	·35	·38	·30	·32	·25	1·88
Total (with sources not mentioned above)	9·80	6·80	16·44	16·62	16·58	15·03	18·15	132·48

3,000 feet in South Africa). But other States, where operations began more recently, play an increasingly important part in the gold production of the United States, of which California only gives a quarter. Table IV. enables us to compare the production of the last few years with that of 1898 and 1890. It demonstrates very clearly the rapid rise in Colorado and Alaska, and the enormous decrease in Nevada. The first of these States to-day is Colorado (yielding

5·91 millions in 1902, 4·68 in 1903, 5·38 in 1904, and 5·27 in 1905), owing to the great centre of Cripple Creek, discovered in 1891 and remarkably developed in the last few years in spite of a depth of working of 1,200 to 1,500 feet. From 1891 to 1894 about 1·32 millions a year were produced, 2·76 in 1897, 2·70 in 1903, 3·32 in 1904. Up to the end of 1905 a total of about 32 millions must have come from this district, and the deposits are far from being exhausted. One of the principal mines is Portland Mine, which by itself yields about ·54 million a year. However, Cripple Creek is far from being the only mining centre in Colorado. Since 1880 the lodes in Gilpin County have been worked, and the deposits of auriferous lead at Leadville supply gold as well (·40 million in 1877—1884, but much more later).

Among the other gold-producing States of the United States, excluding Alaska, which is in a wholly different situation and has been mentioned above, an important place must be given to Dakota, with its rich mines of Black Hills, Homestake, and Golden Reward. The Homestake mine, which possesses by itself 900 stamps and works at a depth of 1,050 feet, treats annually 1,400,000 tons of poor ores, containing on an average 15*s.* a ton—a gross output of about 1·04 millions a year. The amount of ore treated is the largest in the world, and operations, which are always growing, date at least from 1890. I have also mentioned that Golden Reward produces ·24 million.

In Montana and Utah a considerable amount of gold is obtained by refining the copper ores which abound in Butte City (·28 million) and Bingham. The gold output of Montana has passed through a series of fluctuations. It was ·96 million in 1876, ·52 in 1882, 1·08 in 1887, ·68 in 1890, ·60 in 1891, 1·04 in 1905. Till 1880 only placers were worked. To-day a large proportion of the gold comes from the cupriferous ores of Butte (·28 million in 1904). Finally, if we wish to obtain a just idea of the geological distribution of gold in a country where the life of mines is as short as it is in the United States, the older districts must not be forgotten, such as those in Nevada, where in the last six years, after a period of depression, a remarkable revival has been noticed. In this State the famous Comstock mine has produced since 1860 about 40 millions of gold and 56 millions of silver, from one lode alone scarcely two miles long. Eureka, much more limited in extent, produced from 1869 to 1883 4 millions of gold and 8 millions of silver. The total output of the United States from the beginning till 1907 is estimated at about 616 millions.

If we go on southwards, we come to Mexico, where the revival of mining is very recent, especially the development of the gold industry, which only started a few years ago. I have already mentioned above the part played by this country in the past, when rich argentiferous ores were so abundant. A new industrial phase has commenced with the treatment of poor ores, now worked in great masses, and

Mexico has started to become a gold producer of increasing importance. The Mexican output rose from ·06 million in 1888 to ·12 in 1890, 1·71 in 1899, 1·94 in 1900, 2·61 in 1904, 2·99 in 1905, and 3·20 in 1906. The largest mine is the El Oro mine, in operation since 1898, which produces to-day about ·48 million a year.

When we pass to South America we must consider, as I have already remarked, not so much the present insignificant output as the very different results obtained in the past, which will no doubt find a counterpart in the results of the future.

Columbia produced from 1537 to 1902 182 millions, even more than Brazil. The placers of Antioquia and Cauca (El Choco) are celebrated, and lodes are known in the same parts. At present the output remains between ·40 and ·44 million a year.

Venezuela produced about 11·20 millions between 1866 and 1900. It supplies about ·06 million a year. It is here that the celebrated mine of Callao is to be found.

Peru since 1533 has produced about 24 millions, and now produces annually ·07 million.

Chili since 1543 has given rather more than 40 millions. At present the amount is between ·12 and ·16 million, thanks to some placers and the extraction of gold contained in the cupreous masses.

French Guiana has produced about 12 millions, and the British and Dutch Guianas about 12 millions between them. In 1900 the French district yielded ·28 million, against the British amount of ·43 million.

In 1904 the relation was reversed, French Guiana, according to the much too scanty official statistics, exceeding ·39 million, and British Guiana receding to ·28. In 1905 the French district gave ·37, against ·35 for the British. Almost all the gold here comes from alluvia.

In Brazil the working, begun in 1693, has produced nearly 160 millions. The output was very high in the eighteenth century, and then fell heavily; to-day it is rising again to about 11·52 millions. Among the best districts those of Passagem, Carrapatos, Maquiné, Faria, San Juan del Rey (Morrovelho), etc., may be mentioned. A very rough calculation shows that South America must have produced more than 440 millions since the beginning.

3. *Australasia.*—The figure at which we arrive for Australasia from the discovery of its deposits in 1851 till 1907 is nearly 580 millions, and since we found that it was 616 millions for the United States, where the draining process of the gold industry is certainly more advanced, and 440 millions for South America, we see that, contrary to first expectations, gold does not seem to have been too unequally divided between North America, South America, and Australasia.

In the output of Australasia the largest figures were formerly supplied by the older districts of Victoria, but these have already been in existence half a century (since 1856), which is a great deal for Anglo-Saxon mines, and they find it hard to keep up the amount of their output. The large production of Australia has only been maintained in later years by

the help of the new districts of West Australia, discovered in 1895, especially that of Kalgoorlie. The decline of this region since 1903 makes itself felt in the whole total (Table V., where I have reproduced for comparison's sake the output of 1891, already a thing of the past).

West Australia produced roughly ·80 million in

TABLE V. GOLD PRODUCTION OF AUSTRALASIA FROM 1891 TO 1905.
The provinces are ranged in order of their present output.

The totals, taken from local statistics, present some slight differences from those in Table III. (p. 111), which were obtained by converting the data of American statistics.[1]

Australasia.	1891.	1900.	1901.	1902.	1903.	1905.	
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Millions
Western Australia (Kalgoorlie, etc.) ...	·94	43·99	52·98	58·19	64·22	60·81	8·34
Victoria (Bendigo, Ballarat, etc.)	17·92	23·36	22·72	22·42	23·86	23·23	3·18
Queensland (Mount Morgan, etc.) ...	17·87	21·02	18·61	19·92	20·79	18·43	2·52
New Zealand (Waihi, etc.)	7·83	10·54	12·84	14·28	14·92	15·33	2·10
New South Wales ..	4·76	8·74	6·74	5·01	7·92	8·52	1·16
Tasmania	1·51	2·31	2·16	2·20	1·86	2·11	·28
South Australia ...	·89	·62	·68	·69	·65	·90	·12
	51·72 = £6,362,000	110·56 = £15,236,706	116·96 = £16,117,760	122·70 = £16,911,800	134·20 = £18,494,200	129·22 = £17,344,368	

[1] These differences are slightly increased by reconversion into tons and pounds. The totals for 1901, 1902, and 1905 are independent of the details (Translator).

1894, ·88 in 1895, 1·08 in 1896, 2·60 in 1897, 4·04 in 1898, 6·28 in 1899, 6·04 in 1900, 7·28 in 1901, 8 in 1902, 9·04 in 1903, 8·48 in 1904, 8·32 in 1905, and in all 70·40 up till 1907. In this province apparently very rich lodes of gold were first found round Coolgardie, but have singularly disappointed expectations. The practical results have been obtained in the great

district of Kalgoorlie (East Coolgardie), the development of which dates from 1898 (25·70 tons of gold in 1899, 25·56 in 1900, 29·14 in 1901, 31·33 in 1902, 35·80 in 1903), with ores which in 1899 contained on an average 1⅓ oz. of gold per ton. In all Kalgoorlie has produced 36 millions.

The province of Victoria held first place for a long time till the discovery of West Australia. In 1892 the total amount produced was 220 millions (1,786 tons), and should reach 252 millions to-day. The two most famous districts are that of Bendigo, where the mines are over 3,900 feet deep, and that of Ballarat. The Bendigo group had produced in 1892 60 millions (466 tons). In 1854 it yielded 20·57 tons of gold, 6·73 in 1885, and 4·16 in 1892. One of the principal mines in Queensland is that of Mount Morgan (Rockhampton).

New Zealand had produced 48 millions (375 tons) of gold up to 1892. The speculations of 1895-6 closed many of the mines. Nevertheless the output is gradually rising: it was 10·54 tons in 1900 and 15·33 in 1905. The Waihi mine is mentioned as having produced nearly ·60 million in 1904. The Dutch East Indies (Sumatra and Borneo) produce a certain amount of gold.

4. *Europe and Asia.*—We pass on now to the Old World, to the continent of Asia, of which Europe is geographically only an annexe. In ancient times there were certainly considerable deposits of gold there, of which we have already said something in the historical section. The Altai mountains, for instance,

may be considered the oldest source of gold in the world. The Caucasus, India, and Arabia must also have played an important part. But the placers of Central Asia, of the Pactolus, Mount Pangæus, India, Lombardy, and Gaul have been exhausted for centuries, and the poor deposits from which they came have not, as a rule, allowed of any serious working in, our time. The gold production of the Old World is, therefore, excepting the one district of Mysore in India, and Japan, to which I shall return, almost exclusively supplied by Northern Asia, where civilized man had not penetrated in ancient times, that is to say (in order of geographical discovery) by the Ural district after 1814, by Western Siberia after 1829, and more recently by Eastern Siberia, Transbaikalia, the Amur province, and Korea, which in the last few years have made up for the exhaustion first of the Ural and Altai, then of the Yenisei and the Lena mines. For the future we may perhaps count on the countries which either the decay of a civilization widely different from our own, as in China, or the irremediable want of one, as in Turkey, have kept hitherto from making progress. It is estimated that the total output of the Ural district since 1814 is about 56 millions (450 tons), and of Siberia from 1829 to 1905 210·80 millions (1,700 tons). If we take the output for the somewhat distant year of 1876, we see that in this year the Ural district produced little more than 8 tons. Out of 29 tons of gold produced in Siberia 10·30 came from the province of Yakutsk (Oleminsk), 6·30 from the province of Irkutsk (alluvia of the

Upper Lena, the Selenga, Yenisei, and Uderey), 3·83 from Transbaikalia, and 2·80 from the Amur province. In 1894, of 44 tons produced in the Russian Empire, 25 came from Eastern Siberia, and only 7 from all Western Siberia, and 10·60 from the Ural district. In Eastern Siberia 47 per cent. was supplied by the Lena, 40 per cent. by the Amur province, 10·7 per cent. by Transbaikalia, and 2·3 per cent. by the Maritime Province. In Korea the Oriental Consol mines must chiefly be mentioned, in the district of Wunsan. They were closed for a time owing to the Russo-Japanese war, but their output rose again to ·45 million in 1905.

Japan, which is a continuation on the western side of the Pacific of the volcanic tract of Mexico and the United States, has a considerable and rapidly growing output, which reached ·40 million in 1905.

In British India the output, which has grown continuously, stands to-day at over ·24 million a year, two-thirds coming from the two mines of Champion Reef and Mysore.

Lastly, Hungary (Zalathna, Nagybanya, Schemnitz, etc.) remains the only important mining centre in Europe,[1] most of the gold mines—those, for instance,

[1] French and American statistics give for Hungary every year an output of about 3 tons. These figures, which have been asserted to be altogether erroneous by M. de Foville (the real output, according to him, being hardly $\frac{1}{100}$ ton), have been repeated this year in the official communication of the Hungarian Ministry of Finance to the French Ministry of Public Works. There is nothing in them incongruous with the known reputation of the mines, and I have thought fit to adopt them. In Germany, on the other hand, statistics have for many years given 2 to 3 tons of gold a year, supposed to come from native ores, but which really come from imported ores and should be reduced to $\frac{1}{10}$ ton.

in the Alps—having ceased working. If we attempt to arrive at a sum total for Europe and Asia analogous to that which has been given for the other continents, we arrive at about 440 to 480 millions.

France herself, practically speaking, produces no more gold. The Mine de la Lucette (Mayenne) and some other auriferous soils in the department of Aude yielded £12,000 in 1905, and from time to time a little gold is found in the departments of Creuse, Cantal, or Isère. But her colonies contribute from ·40 to ·80 million. In 1900 Guiana produced ·24 million and Madagascar ·13, in 1905 Guiana ·37 and Madagascar ·25, plus a little gold from Bong Miu in Annam (£5,200) and from Indo-China (£2,400).

§ 4.—*The origin of the world's stock of gold.*

To sum up, it is estimated that from 1500 to 1848 about 636 millions were produced by South America, Africa, Brazil, Russia, and Hungary; from 1848 to 1889, after the discoveries in California and Australia, another 984 millions were obtained, and from 1890 to 1907, after the discoveries in the Transvaal, about 880 millions more, making a grand total of about 2,500 millions of gold, or approximately 18,200 tons.

The following table, which sums up this statistical study of the geographical distribution of gold in the world, taking into account as far as possible the production previous to the nineteenth century, shows approximately the part taken up to 1st January, 1907,

by the principal gold-producing countries in this total:—

	Millions.
United States (California, 280; Cripple Creek, 32)	593·2
Australasia (Victoria, 260; Western Australia, 56)	542·4
Russia (Siberia and Ural province)	260
British Columbia	184
South Africa	168
Brazil	156
West Africa	80
Mexico	62
Canada	54·8
Chili	40
China and Korea (?)	40
Austria-Hungary (?)	40
Peru	24·8
British India	14
French Guiana	12·4
Venezuela	11·6
British and Dutch Guiana	9·6
	2,292·8

The difference between the two totals at which we thus arrive is accounted for partly by countries not mentioned in the foregoing table, such as Central America, etc., and partly by the rather vague approximations of certain statistics.[1]

[1] *V.* p. 157 *seq.*

CHAPTER III.

THE EXTRACTION AND DRESSING OF GOLD.

§ 1.—The exploitation of auriferous alluvia — Sluices — Dredging — Hydraulic methods—Frozen alluvia.
§ 2.—The exploitation of lodes—Plans.
§ 3.—The breaking up and crushing of ores—Breakers—Stamp batteries—Tube-mills—Mechanical classification and preparation.
§ 4.—The dressing of gold—Amalgamation—Chlorination—Cyaniding.

GOLD having been discovered in the earth under any one of the forms which we have just passed in review, the next question is how to extract it. This operation, in the case of any metal, is divided into three distinct parts: (1) the work of mining or quarrying, a series of mechanical processes by which the ores are taken from the earth and picked; (2) a more or less fine crushing; and (3) a metallurgical dressing (that is to say, in general, dissolution or fusion), which aims at extracting the gold from these ores. But gold, by reason of the native form under which it is often presented in its natural deposits, has the peculiarity that the mechanical process of extraction is often sufficient by itself, or at most requires to be completed by a very elementary dressing, consisting of amalgamation and refining.

This was especially true in former times when the placers or the altered and superficial forms of deposit in which native gold predominates were attacked.

The exploitation of gold then took one of the simple forms which strike the imagination of the public: the washing of sand in the wooden tub, *batea*, or *pan*[1]; the subjection of the auriferous gravel to the motion of a stream in which the gold is caught on some rough substance, like the famous Golden Fleece; or, on a larger scale, the demolition of high terraces by powerful jets of water, the Californian "giants," while the gold is gathered in one of those inclined wooden conduits with obstacles which are called *sluices*, etc.

The part played by metallurgical treatment in gold mining becomes more marked and developed as time goes on; and the preliminary labour of extracting ore, as the exploitation of lodes becomes predominant, tends more and more to assume the character of simple mining. In a not far-off future it is certain that the working of gold ores will lose the special characteristics which it still can show to become an everyday process of mining, the superficial deposits having been exhausted; the metallurgical treatment alone will remain peculiar. Since it is naturally not my intention here to explain the exploitation of mines where gold is worked in lodes by processes similar to those employed in the working of any ore, it is especially of these peculiarities attendant on the extraction of alluvial gold that I shall speak in § 1; I shall then content myself by summarily noticing (§ 2)

[1] *Pan*, a sort of round iron basin, used by the Americans to concentrate the gold in the sand by one oscillatory motion. The Siberian *batea* is similar, but longer in shape. The *poruña* is a piece of ox horn used in South America for the same purpose.

the characteristic features of certain particularly celebrated mining works proper, such as the Transvaal mines. In the following sections, 3 and 4, we shall occupy ourselves with crushing and the modern metallurgical treatment.

In considering all these technical questions, which have already formed the subject of many large volumes and treatises on metallurgy in all languages,[1] we shall naturally be very brief, and, after a cursory review of the long-known classic methods, we shall dwell rather more on the latest improvements.

§ 1.—*The exploitation of auriferous alluvia—Sluices—Dredging—Hydraulic methods—Frozen alluvia.*

Auriferous alluvia, which may geologically be more or less ancient, are either directly exposed to the light or easy to lay bare by removing barren strata, which are by no means thick, or else deeply buried under plains, in the interior of hills, or even covered by flows of eruptive rock.

In the first case, which has been originally instanced in all the modern alluvia with which the discovery of goldfields began, exploitation is extremely simple. The sands or auriferous gravels are broken up and taken away; then, with more or less perfected appliances, the denser gold is separated from the lighter sands or clays which accompany it by suspending

[1] M. de Launay refers his French readers to Daniel Levat, *L'industrie aurifère* (Paris, Dunod, 1905). For English readers *Ore and Stone Mining*, by Sir Clement le Neve Foster and B. H. Brough (Charles Griffin & Co., 1905), is a very useful treatise on the subject (Translator).

the whole in water and either shaking it up with oscillatory and gyratory motions or causing a current to pass over it. This process, on a small scale, takes the form of the washing in the *batea*, *pan*, or *poruña* conducted by prospectors; the less rough-and-ready but similar treatment in the *cradle* or *long Tom* presents the same principle[1]; in more perfected installations it is the *sluice* (or wooden trough with cross strips to retain the gold), and in antiquity it was represented by the Golden Fleece of the Argonauts.

The *sluice*, which plays a large part in the hydraulic methods, is, in general, an inclined rectangular wooden channel, long enough for the gold, drawn along with the sand by a stream of water, to have time to fall, by reason of its density, to the bottom, where it is caught as it falls by cross strips of wood, or *riffles*.

Advantage is often taken, at the same time, of the facility with which mercury takes hold of gold to fix and retain in this way the very fine particles of the metal which might have been lost (long Tom with amalgamated plates, sluices, etc.). Occasionally, in desert countries, dry vanning is employed to obtain the required separation by the action of the wind.

In the elementary case with which I have begun, the work of extracting and breaking up ores presents

[1] *Cradle or rocker*, a rectangular wooden box with a strainer to which a seesaw motion is imparted by means of two tubs placed underneath. *Long Tom*, a box about 4 yards long by 7 inches broad in which the alluvia are thrown against a current of water while they are broken up with hooks, and the gold is retained by transverse blocks of wood (*riffles*) or on the wool of a sheep's fleece. These two appliances are largely used by the Chinese.

no special feature. It becomes a little more complicated and requires more special appliances when the auriferous alluvia to be extracted are either under the bed of a present river (where dredging can be employed), or in the side of a hill which can be entirely demolished by the hydraulic method, or at such a depth that it is necessary to work by shafts or galleries, following the ancient channels of the auriferous rivers under the earth, and sometimes by special processes for frozen regions like Siberia or Klondyke. We shall successively examine these three cases.

The system of *dredges* or *excavators*, that is to say, mechanical instruments for extraction, which is being introduced more and more in the execution of public works (harbours, canals, etc.), was very naturally indicated for dealing with auriferous alluvia where there were enormous masses of detritus to be moved, broken up, and washed. However, some special difficulties present themselves by reason of the want of homogeneity in the field of excavation, by reason also of unfavourable conditions of industry under which most of the workings of alluvial gold labour in new countries where the smallest damage is difficult to repair, and, finally, by reason of the necessity of passing regularly through the dredges an immense daily bulk of material and, in consequence, of having a very vast field assured if the working is to be profitable.

The first favourable results from the employment of dredges were obtained in New Zealand and in

Australia after 1889. From this time onwards the process became general, and is now sometimes used even in placers watered by a simple brook. M. Levat introduced it into Guiana and Siberia; it has been applied likewise in California, British Columbia, Alaska, etc.

At first, and up to quite recent times, almost all the dredges were worked by steam; recently electric dredges have also begun to be used. Usually the extraction of the alluvium is carried out by means of a chain of buckets. The alluvia then pass, on the dredger itself, into a "trommel" sifter which sorts the materials, and these then go into a sluice from 8 to 10 yards long, after which the tailings are removed by an elevator placed behind. Excavators are also beginning to take their place in practice, notably at Klondyke.

The *hydraulic method*, employed for the first time in 1852 in California, consists, as we know, in demolishing entire hills by means of a kind of hose pipe, the "giant" or "monitor," into which water is driven under high pressure. This astonishingly powerful current of water is directed on to a vertical section of the mountain which it has itself laid open and which gradually recedes before it. The water, which often flows at a rate of fifty yards a second, and the volume of which may reach 150,000 cubic yards every 24 hours, succeeds in piercing the hardest rocks. The result is a torrent of mud which carries along the gravel and flows out by a tunnel starting from the bottom of the auriferous beds; there it undergoes a separation by which the gold is obtained. Naturally, this method

is only applicable if there is a slope and the disposition of the ground furnishes a natural outlet for the torrent of mud (which is rare), or if by means of an artificial tunnel, often very long, such an outlet can be made. The difficulties of the method consist, first, in the cost of installation (the damming of valleys to make reservoirs, the construction of conduits or *flumes*, and of tunnels for letting the water down to a lower valley, etc.), and, secondly, in the disposal of the enormous quantities of *débris* which result.

This question of *débris* has caused the method to be almost entirely forbidden in California, by reason of the devastation caused in great agricultural districts. In a very lively electoral battle in which the miners and farmers took opposite sides the latter were victorious and passed the Débris Act of 1884, prohibiting the method and so rendering vast masses of auriferous ground useless, no doubt for a long time, till a change in the conditions. In other countries, like Klondyke, Cape Nome, and New Zealand, the hydraulic method is still in use. It is to be feared that it will be prohibited in New Zealand also, owing to the progress of agriculture, and that its use will be thus restricted to the desolate regions of the Arctic zone, where the question of water supply, in its turn, presents no small difficulty. In any case, the ravages caused in California suffice to show that "hydraulicking" cannot be thought of in countries like the Po valley, the plain of Granada, etc., where the ground unquestionably contains some traces of gold, but where agriculture is too evidently dominant. The

hydraulic method, none the less, retains its interest for the scale on which it works, of which a few figures will give an idea. In the case of reservoirs, a capacity of 20 to 30 million cubic yards has been attained at a cost of from £40,000 to £80,000. For conduits, a length of 310 miles and a cost of £400,000 has been reached: 62 miles and £80,000 have often been exceeded. The jets of water, as I have just stated, are driven at the colossal rate of 150,000 cubic yards in 24 hours, with a speed of 50 yards a second. As to the outlet tunnels, several have reached a length of five furlongs and cost over £28,000. The cost of production, which is very small, may in exceptional cases go as low as 1½*d.* or 2*d.* the cubic yard of gravel treated.[1] In the northern regions, such as Klondyke or Cape Nome, the difficulty is to find water under pressure, since the water, caught on the mountain heights, fails as soon as the summer advances a little. The idea has been mooted of raising water with steam pumps, but, in view of the scarcity of combustibles, this implies considerable expense which could only be balanced by high productivity.

Lastly, the subterranean working of auriferous alluvia by shafts and galleries (*drift mining*) was from 1855 to 1870 conducted on a large scale in California, where by this means a whole subterranean network of Pliocene auriferous rivers was gradually revealed. Neglected for a moment, it regained its importance after the prohibition of the hydraulic method. With

[1] A hydraulic working in N. California recently treated, at a small profit, alluvia containing 1½*d.* worth of gold to the cubic yard.

this system it is impossible, in ordinary conditions, to go below 30 grains of gold or 5*s.* 5*d.* the cubic yard. Subterranean working takes a special character in the deeply frozen regions like Transbaikalia, Klondyke, and Cape Nome. In these regions, the mean annual temperature remaining below freezing point and the number of cold days being much higher than that of warm days, the conductivity of the earth causes a continuous penetration of the refrigerating action, so that the low temperature reaches lower and lower levels. Under such circumstances the ordinary processes of breaking by pick or by explosives have no effect, and the work can only continue after thawing by fires in spite of purely local effect of such heating. In Siberia this thawing process has remained very rudimentary and is conducted only by burning heaps of wood. Empirically, the thickness of the firewood used at the foot of the alluvium is equal to that of the ground which the burning of this wood succeeds in thawing. Shafts are first sunk by means of fires; these are connected by galleries in the auriferous bed, and the masses enclosed by these galleries are successively broken up. In every case the fire is kept up till the desired effect is produced: then it is stopped, and breaking proceeds with the pick. Elsewhere, as at Klondyke, the method has been perfected by using points, that is to say, tubes heated by steam by means of a pulsometer. These tubes are lengthened gradually as the ground melts, and are used both for sinking shafts and piercing galleries. It is to be noticed that in these frozen districts the ground is sufficiently

resistent and at the same time sufficiently plastic to allow of passing even under the river beds, thus economizing in planking. Nevertheless the extraordinary dearness of living is such that workings by steam thawing on a large scale are impossible at a yield of less than £2 10*s.* to the cubic yard.

§ 2.—*The exploitation of auriferous lodes—Plans, etc.*

In speaking of alluvia we have already indicated some methods of subterranean working. The methods are, in this case, very simple and consist in reaching the almost horizontal auriferous layer by small vertical shafts, tracing galleries in this layer, and breaking up the intervening masses by some means or other. The case of lodes or interstratified layers taking the form of lodes, like the banks or "reefs" of the Rand, is different. The exploitation then reverts to the ordinary type of working employed for metallic veins. It is out of the question here to give a discourse on the exploitation of mines; but I shall rapidly indicate what special features the problem to be solved may present in the case of gold.

The auriferous lodes may be more or less upright and near the vertical. In general these lodes are reached by vertical shafts which are connected with the lode by horizontal galleries drawn at right angles to it through the barren rock, and these galleries are called cross-cuts: or, if the lode is enclosed in the side of a mountain, these galleries start immediately from the open without the help of shafts. When, in one way or another, the lode has been reached at a

given level (which can sometimes be done immediately, beginning from the surface, in the case of lodes the outcrop of which appears on the side of the mountain), the lode is followed by level galleries, connected from time to time by perpendicular galleries or chimneys following the line of the greatest slope. A deposit is thus "prepared" and "traced," just as if we wished to demolish the compact mass of a town, and began by tracing streets in it in order subsequently to attack the blocks of houses.

On the Rand, where the layers of auriferous conglomerates have a variable slope which, in general, nears the horizontal at the lower levels, vertical shafts were replaced by inclined shafts following this slope and sunk in the auriferous layer itself. Cross-cuts were thus saved, the horizontal levels being immediately pierced from the shaft in the layer. At least this is what was done there at the start in the case of the so-called first-class concessions, which had the outcrop of a lode. In the case of those situated at some distance from the outcrop and excluded from the use of it, which subsequently aimed at finding the deep-seated continuation of the vein in workings called "deep level" workings, the normal method of vertical shafts was returned to, at least till the vein was found, and this once found, it was generally followed by inclined shafts.

However it be effected, this preliminary labour of "tracing" must be succeeded by the breaking up of the masses, which constitutes the "working away." This working away is usually effected by means of

drills which serve to cut holes for the employment of powder or dynamite.

The two most important points concerning the working of auriferous lodes are the preliminary measurement and the assessment of what is called the "ore in sight," which must have been first revealed by preparation or tracing before the working away. The "ore in sight" is the ore which can be affirmed to exist and to be workable at a profit. In order at the same time to determine its presence and value, in most of the well organized mines a methodical sampling is carried on, with exploratory probings taken at equal distances along all the galleries which allow the ore to be reached. The results of these probings are analysed in the laboratory, their percentage of gold is noted, and according as this or that specimen is above or below the working limit, a mark is made on the plan "paying ore" or "barren." The process even goes further, and the exact value of the sample is analysed so as to make it possible, if necessary, to note on the plan the line of increased productivity, the direction of the mineralized columns or lenticles which a lode usually encloses, and especially to know in what direction the breaking up must proceed to raise or lower the mean productivity. It is in this manner alone that a well-conducted mine, its preparatory works being sufficiently advanced, can succeed in balancing its output and avoiding those sudden jerks which, even when they are not systematically sought with a speculative aim, as too often happens, have a most deplorable effect upon a rational industrial development.

§ 3.—*The breaking up and crushing of ores—Breakers —Stamp batteries—Tube-mills—Mechanical classification and preparation.*

THE CRUSHING OF ORES.—When the ore has been taken from the lode and brought to the daylight, it remains to extract the gold, which most often is not even visible in these shapeless stones, pyritous quartz, schists impregnated with metallic sulphides, conglomerates of quartzose pebbles stuck and, as it were, melted together, or these rocks with scattered veinules or crystals of fluorite and tellurides. The treatment of gold ores comprises, first, if necessary, as in all ordinary cases, their breaking up and crushing into more or less fine powder; then the extraction of gold by various processes, the chief of which are amalgamation, cyaniding, and chlorination. These operations of metallurgy proper, which are commonly founded on the solubility of gold in various reagents, will be studied further on; it is first necessary to get the ore into a fit state to undergo them, that is, to reduce it to sufficiently minute fragments that the dissolvent may be able to act upon it.

The question of crushing has even to be considered in the case of certain alluvia and cemented gravels, which are sometimes left to be broken up by the action of the air, and at other times passed through breakers. But it only assumes its true interest in the case of lode ores in which the gold, as we have seen, is generally enclosed in a very hard gangue of quartz. In theory, the nature of the auriferous ore matters

little so far as this crushing is concerned, but in practice the nature of the ore determines the degree of fineness to which it must be reduced. Clearly less fineness is required in the case of ores of free gold, on which mercury can be made to act directly at the bottom of the stamp mill itself, than when complex or refractory ores are attacked which are destined to a long subsequent treatment. In all the auriferous countries which have left the early heroic stage to employ properly industrial methods, the need grows more and more pressing to extract all the gold contained in the ores, and not only the free gold separated at once by its density or by amalgamation—to extract, that is, 40 to 50 per cent. of that gold which at first is often lost in the *tailings*, or residues, of the first operation. The result of such an advance is not, in fact, reckoned solely by the increased return from the ores treated, but more particularly by the possibility of working masses of poor ores otherwise valueless; and the utilization of these tailings requires, as a rule, a very perfected crushing, to which in recent times attention has been very specially turned in the Transvaal, Australia, the United States, etc.

The classic and almost universally adopted method of crushing auriferous quartz hitherto has always been, to begin with, the *stamp mill* (Californian mill). In a very great number of cases, when the gold is in a free state, this stamping, which is combined with an immediate amalgamation, has appeared sufficient by itself, and even for more complex ores it remains,

as a rule, the first operation by which all the amalgamable gold is easily removed. These machines are described in all the books; I shall, therefore, content myself with recalling their principle.

The ore, which is first crushed to 40 millimetres in Blanc jaw-breaker, or gyratory breaker, is then reduced to 15 millimetres in a Bartsch breaker. In the jaw-breaker the fragments of rock are caught between two steel jaws with toothed edges, one fixed and the other moved backwards and forwards by an eccentric. The gyratory breaker presents an inner cone of ribbed steel, turning round a vertical axis inside a fixed receptacle. The Bartsch breaker also has two jaws. After this preliminary operation of reduction the ore passes under the vertical stamps, which are generally grouped in a battery of ten and raised vertically by means of a cam-shaft. These stamps rise and fall with a deafening din, crushing the ore mixed with water in a cast-iron mortar, in which the addition of a little mercury produces a preliminary amalgamation. The crushed material mixed with water, which is called the pulp, runs out through a screen on to an inclined plate of silvered and amalgamated copper, the same width as the mortar itself, or $1\frac{3}{5}$ to $2\frac{1}{5}$ yards. The gold is retained in the state of amalgam. At regular intervals the amalgam is gathered by scraping the plates and it is distilled to separate the volatile mercury from the gold. The present tendency is to employ heavy stamps (880 to 1,210 lbs.) and to make them beat rapidly (90 to 96 strokes a minute) with a small drop ($5\frac{1}{2}$ to 7 inches).

Occasionally, in the last ten years, breakers with bullets have been substituted for stamp breakers, and horizontal cylinders of steel, like those used to crush macadam, are sometimes used, notably at Cripple Creek and Australia. An important advance, which the development of cyaniding made necessary, has been lately made by the addition of a finishing machine to these preliminary crushing machines. This is the *tube-mill*, which reduces very considerably in grain the crushed materials forming what is called the pulp.

The advantages of the tube-mill are of three kinds: (1) this complementary crushing allows the stamp crushing to be restricted, its duration to be limited, and the crushing capacity of a given battery to be increased; (2) the tube-mill, by making the crushing more perfect, leads to a more complete extraction of the gold; (3) the extraction by cyaniding takes place more rapidly. By this means, therefore, there is both a net profit on the gold produced and a diminution in the cost price owing to the greater amount of work done by a given series of cyaniding vats. The machine which produces these results is a "tube crusher," that is to say, a cylindrical bullet crusher, consisting of a large closed cylinder, rotating round a horizontal axis and containing movable crushing instruments (most usually pebbles of quartz, more rarely steel bullets), into which the ores to be finally crushed are introduced at one end to be collected at the other and subjected at once to the cyanide treatment. The machine is provided with an inner lining of very hard

silex. The usual dimensions in the Transvaal are $6\frac{3}{5}$ yards long by $1\frac{1}{2}$ in diameter; the speed of rotation is about 24 to 27 turns a minute. The ores pass from the stamps to the tube-mills, then to the sorters, and then to the cyaniding apparatus.

The results obtained in 1905 with these machines were so encouraging that sixty were immediately installed or ordered on the Rand. It is estimated, in fact, that by this means it will be possible to increase by 2 to 3 per cent. the proportion of gold extracted. The tube-mill is a preliminary finishing machine, intermediate between the stamps and the cyaniding. It is at this intermediate stage also that the work of mechanical preparation and separation takes place which is to separate and class the residues of crushing and amalgamation, so as to subject them, as may seem fit, either to chlorination or to cyaniding.

MECHANICAL PREPARATION.—When the crushed ore, the pulp, has passed over the amalgamating tables, which succeed the stamps, its treatment is not terminated even in the case of free gold, or *free milling ores*. One part of the gold has been carried away in fine floating grains (*floating gold*) by the current of water; another remains incorporated in the residue or *tailings* which escape from the amalgamating table. The point is to recover as much as possible of this lost gold.

With refractory ores, in which gold is not presented in an amalgamable state, either owing to its combination with tellurium or its mixture with iron pyrite and various sulphides, called "sulphurets," or by the

presence of arsenic, antimony, bismuth, and lead, or simply because it is in a state of ill-defined combination in presence of silica or oxide of iron (Mount Morgan), the treatment of these tailings by cyaniding or chlorination becomes more indispensable, and it is therefore in every way necessary to resort to a methodical sorting and concentration of them. This is done by a series of machines employed generally in the mechanical preparation of ores—Rittinger side-blow shaking tables; shaking belts of endless india-rubber sheeting or *Frue vanners*; Wilfley tables, which are rigid and covered with linoleum with a series of longitudinal strips of unequal length and varying height, the *riffles*, between which, by means of a rapid reciprocating motion, the heavy metalliferous particles accumulate, while the barren passes over them; and, finally, by *round-buddles* and turning tables.

All these appliances, which are not special to the treatment of gold, but are employed for all ores—and it would be beyond the mark to enter into their detail—rest on the same principle, the maintenance of the crushed matter, or "pulp," which contains the gold, in suspension in the water, and the separation of the heavy gold from the lighter barren stuff by taking advantage of its density. The application of this uniform principle may be different according to the fineness of the pulp and the nature of the barren vein-stuffs. Sometimes the separation is operated by simple vertical shaking over a sieve, the gold, being heavier, falling more quickly to the bottom; sometimes a reciprocating movement in a horizontal

direction is employed, the shocks moving a slightly inclined table, the form and nature of which may vary; sometimes, again, centrifugal force is utilized in a revolving truncated cone. In general the current which carries the pulp in which the gold is hidden falls at a carefully regulated speed upon an inclined surface of wood, cloth, or indiarubber, sometimes smooth, and sometimes furnished with obstacles to catch the gold. To this inclined surface either simple transversal shocks are imparted or a longitudinal displacement as well in the opposite direction to the slope and the current (*Frue vanner*). This transversal motion combines with the relative velocity of the current following the slope to cause the materials, originally mixed together, to describe different curves according to their density: by this means they are separated. The result is that it is possible, either immediately in different compartments, or a little further on in the filtering basins, to collect the materials classified in order of their density. This density, in the case which we are considering, practically represents their richness in gold, or at least their richness in metallic substances.

By this means enriched products are obtained which are called the *concentrates* (pyrite and gold), while, on the other hand, the very fine residues escape, the extreme fineness of which counteracts the force of density. The very fine particles, which are with difficulty filtered subsequently and then washed by clearing liquids in order to extract the gold by dissolution, form the *slimes*; to perfect the

treatment of these slimes and to extract the very last trace of gold which they contain most strenuous efforts are made, but the problem has long presented, and even now often presents, serious difficulties.

§ 4.—*The dressing of gold—Amalgamation—Chlorination—Cyaniding.*

The dressing of gold, contrary to that which has up to now taken place for most of the other metals, is not an igneous dressing, except in the case of complex cupro-auriferous ores or plumbo-argentiferous ores with traces of gold, in which gold is the by-product of operations primarily conducted with a view to obtaining another metal. It consists in the use of dissolvents, of which the first historically was mercury; then came chlorine, and lastly cyanide of potassium.

(1) AMALGAMATION.—It is unnecessary to spend much time upon the use of mercury. Amalgamation, which is the fixing of gold in the state of alloy with mercury, is associated with and added to the previously mentioned processes—simple washing in sluices or crushing in stamps—and its principle is extremely simple. It consists in combining gold with mercury to separate it from other barren substances and then distilling it to separate the two metals. But it is known that a great many ores escape the effect of this amalgamation, which is counteracted notably by arsenic, antimony, bismuth, lead, etc., and it is these refractory ores which have intervened since 1890 more and more in the production of gold and caused

its astonishing development. It is these also, as I have already said, which will take more and more overwhelming part in the gold industry of the future. The process of chlorination was used on a large scale long before that of cyaniding, but it is tending to die out, while the latter process is one which, with its continuous improvements, some of which are quite recent, has caused a veritable revolution in our gold-mining.

(2) CHLORINATION.—Chlorination consists in combining gold with chlorine to obtain a soluble chloride of gold, from which it is then easy to extract the metal. Among the numerous systems of chlorination tried by Elsner, Plattner, Mears, etc., all those which employed a chloruretting roasting with common salt have been abandoned owing to the loss of gold which resulted. On the principle that gold is commonly enclosed in a sulphide of iron, chlorination always begins to-day with a very careful oxidizing roasting in which nearly the whole of the sulphur, arsenic, and antimony is eliminated. All the metals, except gold, pass into a state of oxides, iron especially; at the same time the organic combinations which may exist are destroyed, and the water enclosed by crystallization, often very injurious to amalgamation (Mount Morgan, etc.), is eliminated. The ores for which such roasting is in every case necessary, even if the cyaniding treatment is to be used afterwards, are practically the only ores for which the process of chlorination seems now to be indicated.

After crushing and roasting chlorination proceeds, and then the gold is precipitated in solution by some reducer. The processes differ both in the way of obtaining the chlorine and in the choice of a reducer. In the Plattner process, used towards 1895 in the Transvaal, the chlorine was produced by the action of sulphuric acid upon a mixture of dioxide of manganese and common salt; the chlorine was combined with the gold in a wooden vat lined with lead; the yellow liquor of chloride of gold was filtered and the gold precipitated by reduction with sulphate of protoxide of iron. In the Newbury-Vautin process, the most commonly used at present (Mount Morgan, Cripple Creek, etc.), the chlorine is obtained by the action of sulphuric acid on chloride of lime, and the gold is precipitated either by a charcoal filter (Mount Morgan) or by sulphuretted hydrogen. Lastly, at Cripple Creek they have begun to produce the chlorine in a much more economical way, by the electrolysis of common salt, a method which, according to M. Levat, would give a cost price of 3*d.* a kilogramme (2·20lb.) of chlorine liberated.

At Mount Morgan (Queensland), where the ores are extraordinarily rebellious to amalgamation, good results have been obtained in practice by a light roasting after passing the ores through cylindrical crushers; these are then treated in revolving barrels with a mixture of sulphuric acid and chloride of lime and reduced in a charcoal filter. At Cripple Creek (Colorado) the oxidized ores, marked by the presence of tellurium, are now treated, about $\frac{3}{4}$ by chlorination,

$\frac{2}{3}$ by cyaniding, and $\frac{1}{3}$ by fusion. The use of chlorination, contrarily to the general rule, here tends to increase. The ore for chlorination is crushed very fine in the cylinders, then roasted in automatically stoked furnaces which take 60 to 100 tons in 24 hours, and then treated in barrels as at Mount Morgan; after which the gold is precipitated by sulphuretted hydrogen.

(3) CYANIDING.—The principle of cyaniding, to which we now come, is extremely simple; it consists solely in employing the well-known solubility of gold in cyanide of potassium, and in then precipitating the gold by reduction or electrolysis. However, the patent of MacArthur and Forrest for the application of this method only dates from 1887, and the first results, except on the Rand, appeared very discouraging, owing to the very numerous practical difficulties in the application; but on the Rand they were so successful that all the mines adopted the process,[1] and from there it has spread all over the world, and its successive improvements have gradually brought it to a state of semi-perfection. The success of this method depends both on the chemical composition of the substances treated and on their physical state, or their capacity for being filtered. Chemically, the presence of certain metals like copper, which counteract the operation, and the acidity, or the amount of alkali

[1] We know that cyaniding, which arrived just in time when the *free milling ores* (directly amalgamable gold ores) were beginning to fail, saved the Transvaal, where without it a very small number of mines would make a profit.

necessary to neutralize the sulphuric acid produced by the decomposition of the pyrites, have to be considered. The acid sulphates, in fact, produce cyanhydric acid, giving with the gold an amalgam not subsequently precipitable by zinc. For certain sulphuretted ores a preliminary roasting is necessary. Physically, it is essential that the tailings to be lixiviated should be well screened, and if their compactness opposes the passage of the cyanided solutions, they must be held mechanically in suspension.

The present practice in the Transvaal is based upon the fact that the fineness of the grain greatly increases the proportion of gold extracted, and efforts are therefore made to obtain substances crushed as finely as possible for cyaniding (whence the use of the tube-mills described above). For this purpose they begin by extracting the greatest possible amount of gold by an amalgamation following the crushing in breakers and stamps, as has been described above, but relatively coarse, after which they recrush all these materials, sands (tailings) and fine mud (*slime*), very fine in a tube-mill and cyanide them. The matter to be cyanided is very carefully sorted in order of fineness, in order to treat the tailings, on the one hand, quickly with concentrated solutions, and to subject the slimes, on the other, to a longer process with enormous volumes of very weak solutions. At the end, all the gold which has not been obtained by amalgamation is found in the state of cyanided liquid, from which it is easily extracted.

This, it is to be remarked, is a notable change from the method used in 1895,[1] when the treatment of these slimes had hardly begun, and the aim was, consequently, to obtain by crushing the greatest possible amount of sandy tailings, a little finer than those which go to the tube-mill to-day. The recovery of the gold contained in the slimes has raised the total coefficient of extraction from the ores from 80 to 92 per cent. In practice the residues, once they are sorted and divided into classes, are raised by great 60-foot water wheels high enough for them to pass through the series of cyaniding vats on their descent. They are then poured by distributors with movable arms into vats of wood or sheet steel, from 6 to 12 yards in diameter and from $1\frac{1}{3}$ to $2\frac{1}{2}$ yards high, where they are exposed to a cyanided solution which filters down through a double bottom covered with a mat and a sheet. The cyanided solution is far more diluted with water than one would think: ·30 per cent. is a strong solution for the concentrates; for the finer stuff it goes as low as ·08 per cent. Usually the strong solution is made to act first, then the weaker solution to catch the residue, and the treatment lasts about three days. The process requires about 6 to 10 cubic yards of cyanided solution to a ton of ore. The gold, having been obtained in the state of cyanided liquid, is precipitated either by zinc (the MacArthur-Forrest process) in wooden boxes divided into a certain number of compartments (extractors), or by employing electrolysis

[1] L. de Launay, *Les Mines d'Or du Transvaal*, 1896, p. 441.

(the Siemens-Halske process) with negative electrodes of lead, on which the gold is deposited, and positive electrodes of iron.

In other countries, such as West Australia and Cripple Creek, the whole process is preceded by an oxidizing roasting, which might perhaps be more generally employed with profit. At Kalgoorlie the special process of the *filter-press* has been devised. Certain refractory ores in this district (Great Boulder) contain gypsum, magnesium, and calcite, which rendered the old systems of treatment ineffective. An attempt to agitate the pulp by compressed air in the cyaniding vats did not give good results. The method of the filter-press was then invented, and is applied after breaking, crushing, roasting, and a preliminary cyaniding in vats furnished with agitators. The pulp is compressed into a cake in a press holding six tons of material, so as to extract as much as possible of the 55 per cent. of water which it contains. Compressed air is passed over it for ten minutes to oxygenate it, and then a highly compressed ·08 per cent. solution of cyanide for 25 minutes. It is then aerated once more and washed in pure water.

At Cripple Creek, where the ores are telluretted, the preliminary roasting aims at diminishing the time of contact with the cyanide and the loss of cyanide, while at the same time increasing the proportion of gold extracted.

In conclusion let me just add a few figures for the cost price of these various metallurgical processes. In an important and widely opened mine, as I have

said above,[1] ores of free gold may be treated at a cost of 10*s.* a ton, but very often this figure is doubled or more than doubled. The cost in certain Californian mills is £1, and it is much more in countries like British Columbia. In the case of the chlorination applied to the telluretted ores at Cripple Creek, the cost price is about 12*s.* 9*d.* to 16*s.* a ton; at Mount Morgan a similar treatment costs 14*s.* 8*d.* a ton. In the Transvaal, with cyaniding, the cost of working and treatment (not including the cost of machinery) varied in 1895 from 17*s.* 7*d.* to £3 4*s.*, and the average was from 25*s.* 7*d.* to 28*s.* a ton. The British conquest increased the cost at first; but industrial progress is gradually compensating for the evil effects. Without striking an average, which would have no real value in the case of such variable elements, the cost of working (to which for an accurate estimate a tax of 10 per cent. on the profits must be added) is at present, in very many companies, from 20*s.* to 24*s.* 9*d.* (20*s.* in Robinson Deep, 21*s.* 9*d.* in the City and Suburban and Crown Deep, 26*s.* 4*d.* in the Nourse and Ferreira Mines, and 30*s.* in the Wemmer Mine); 24*s.* to 24*s.* 9*d.* is a very common figure, which is brought by the tax to about 26*s.*[2] These prices, however, are very high in relation to those of other districts where cyaniding is also employed.

[1] P. 48.

[2] These figures are for metric tons; *v.* Translator's preface.

CHAPTER IV.

THE ECONOMY OF GOLD.

§ 1.—Statistics relating to gold.
§ 2.—General ideas on the commercial aspect of gold.
§ 3.—The industrial uses of gold—Wear and tear.
§ 4.—Gold currency and bimetallism—The proportion of gold used for currency — Systems of fiduciary circulation — The stocks of coin in various countries.
§ 5.—The purchasing power of gold—The fluctuations in its value—The complexity of the problem—Purchasing power measured by the cost of living—Comparison with other metals.
§ 6.—The present evolution of the gold industry—The causes and consequences of its development—Economic and political influences on the present development of the production and consumption of gold: Colonial expansion, the Boer war, the penetration of China, the abandonment of bimetallism, etc.—The immediate and the more distant prospects of the gold industry—Economic and social consequences—Interest—The future of capital.

LET us now consider for a moment the point to which we have arrived. In the first chapter upon geology we saw how gold is distributed in the earth's crust, under what forms and in what state of mineralization it is found there, with what metals it is combined or with what mineral substances it is associated; we inquired as to the probable mean percentage of gold in the continents and seas, and as to the reserves of gold which are presented in the immediately accessible parts of the earth's crust, not to mention those which the earth may hide in its depths. We then examined the geographical distribution of these auriferous ores, in the past as well as

at the present; we passed in review the countries and continents which have produced or produce gold, while striving to fix the respective importance of these various abnormal concentrations in which, here or there, a greater or less quantity of gold has been collected. We also saw how rare and how strictly localized in a very small number of places the very rich concentrations were—a fact which shows the exceptional character of the phenomenon and which is consistent with the hypothesis of its primary origin at some depth, which is supported by so many other points of evidence. We insisted, further, on the precarious and ephemeral nature of those gold workings which for a brief moment dazzle the imagination, thus demonstrating both historically and logically that, if we wish to find abundant and easily extracted gold, it is necessary to go and look for it in regions difficult of access to which, for some reason or other, civilization has not yet penetrated, and which may be called its advanced "marches."

Considering then, from another point of view, ideas of the same simultaneously geological and geographical orders, we showed how the poor ores tended more and more to play a predominant part, as the fields still untrodden by the explorer diminished in number, and how this industrial development was still further accentuated by the growing facilities for treating such ores which are given by the daily advances in metallurgy described in the last chapter. Also, as regards these poor ores, we pointed out how quickly the quantity at our disposal increased as the

limiting percentage of gold, which is determined by the cost of extraction, decreases; how fictitious, empirical, and momentary is the barrier set up between paying ore and barren; and how, in consequence, the earth has in store for us considerable quantities of ores with lower and lower percentages, which will be at our disposal as soon as we care to pay the price necessary for their treatment, either when this price has sufficiently fallen owing to metallurgical progress, or when the value of gold owing to greater scarcity has sufficiently increased.

Finally, in the last chapter we briefly described the methods of extraction, mechanical preparation, and metallurgical treatment employed for gold ores; we found the present cost of methods most extensively used in the most famous mining centres, and mentioned the recent improvements which may have the effect of reducing this cost price.

We shall now have to recall the principal conclusions of these chapters to draw economic conclusions from them, with the aid of some new sources of information, which are first to be considered.

The problem of gold, of supreme interest and importance to all classes, rich and poor, capital and labour, directly or indirectly, is, briefly stated, the following: What quantity of gold will the world produce in the next few years, and what will be the consequences of this influx of gold, what its impact and recoil, and what the effect of its possible interruption in the future? These movements, even if they are not so immediately visible as those of an increase

in the price of bread or of coal, have none the less a powerful influence on all economic, financial, and social questions.

The order which we shall elect to follow will lead us first to examine the way in which the commercial exchange of gold is effected, the industrial uses of gold beyond that of currency, and the degree of necessity in its use as currency. This amounts to estimating the consumption of gold that is to balance its output, or, to put it otherwise, the demand for gold which, by acting against the supply, finally determines the price, the fluctuations of which we shall try to follow. We shall then turn our attention to analysing the causes and effects of the present increase in the gold output, in order to estimate its duration and to foresee the consequences that must attend its prolongation or its interruption. We shall next try, in conclusion, to examine the effect which a probable increase or a possible decrease in the value of gold would produce on society as at present constituted.

§ 1. *The statistics relating to gold.*

All economic studies concerning gold must necessarily rest upon statistics, the principal results of which we have already reproduced. Now any one who has ever had occasion to study any statistics knows the large element of approximation which enters into figures apparently so exact. It is therefore perhaps not superfluous to consider briefly the real means by which we are informed as to the production and commercial exchange of gold.

The output of the gold mines is, in general, in every civilized country, subject to an official declaration and an official control, as is the case with most of the mineral sources of wealth. Since this declaration is usually the basis of a tax, we may expect a certain degree of fraud, especially on the part of the small producers. However, the error on this head is perhaps not very large in the great mining centres and in countries where there is a large turnover. In fact, the interest of the mines lies all the other way, in not depreciating their apparent output, since this, to a very large extent, and particularly during the ascending stage of the industry, forms the basis of their value on the Stock Exchange. The gold output is frequently given (for many districts monthly) in communications to the shareholders, and the tendency is rather to exaggerate, especially by manipulating the amounts of *fine* gold and *crude* gold, or *bullion*, which may often differ from one another by 10 to 20 per cent. The gold of the mines or placers is not fine gold before refining; it contains a more or less high proportion of foreign metals, silver, copper, etc., and as refining does not in general take place on the mine, but after the gold has been sent to some great industrial centre in Europe or the United States, while the metal leaves the country of its origin in a crude state, it is easy to increase the figure of the output by a slight inaccuracy as to the proportion of fine gold contained. Even in the Transvaal, where all the returns relative to the output of the mines are made out in great detail and with

particular care, this vicious practice of announcing the output in crude gold has not long been replaced by the present more exact quotation in fine gold.

Another cause of error which often interferes in other industrial statistics does not affect the case of gold. The extraction of gold, owing to the special nature of the substance produced, is an industry carried on in the full light of publicity; there is no question of competition between neighbouring producers, and no producer has any industrial interest in concealing his processes, his assays, and his results. Financial considerations alone could cause a falsification of returns, and that always in the same direction by tending to exaggerate the apparent output in order to obtain credit.

In the countries, therefore, where a regularly organized administrative control of the mines exists, its published returns may often inspire us with a comparative degree of confidence. However, one serious cause of error presents itself, even if we neglect for the moment countries like China where no such control exists. This cause is theft, which takes place to a considerable extent in all gold fields, though its prevalence may vary slightly with the country and the degree of surveillance. Theft is particularly easy in the case of a substance which commands so high a price for so small a weight, and which it is so easy first to hide and then to sell, since it is a universal commodity. Whether it be gold dust stolen on the placers by the labourers engaged in mining or amalgam pilfered in the workshops at the time of the

monthly scraping, a considerable proportion of the gold extracted escapes its legitimate possessors and, in consequence, the statisticians. Even in a case such as that of the Transvaal, where the gold industry is highly localized, highly centralized, and particularly easy to supervise, this problem of theft has exercised men's minds for a long time without their having been able to arrive at any complete solution, and though an exact estimate is naturally impossible, the amount of gold thus stolen has been put at 5 to 10 per cent. It is still more natural that theft should be extremely prevalent in a country like Siberia, where the labourers are far more isolated and the corruption which is the rule from top to bottom of the official ladder induces every one to profit by favourable opportunities. According to M. Levat,[1] the quantity of gold stolen in Siberia is not less than 20 per cent. on an average, so far as can be judged by comparison between the products of a directly supervised washing and a washing conducted under the ordinary conditions. "The habit of stealing," he says, "is so ingrained in the Siberian miner employed on the placers that the severest regulations produce no effect; but that is not all: the labourers prefer to get themselves employed on the placers where the officials shut their eyes to theft, but either fleece the men in the canteen or cheat them with scanty or damaged rations." What M. Levat does not add, but what it is easy to read between the lines, is that

[1] *L'Or en Sibérie orientale* (Rouveyre, 1896), Vol. I., p. 60; Vol. II., p. 34.

in this last case the labourers are not the only ones who steal. Naturally frontier districts are particularly propitious to these clandestine transactions. In Russia the Government requires that all the gold produced in the Empire should be brought to its mints. It is the purchaser of gold at a price fixed in advance in order to increase its reserve of gold ingots, and at the same time it exacts a variable tax on the gross produce of the mines. One might therefore suppose that all the gold extracted would pass through its hands. Nevertheless a great part of it eludes this double control, especially in the region bordering China, where the miners have too many facilities for taking away their gold without declaring it.

Besides, even in a relatively civilized country like the Russian Empire, genuine clandestine or illicit workings, sometimes organized on a large scale, must be taken into account. Only lately (1896) a crowd of 4,000 adventurers descended upon a placer on the Zeya, which had been conceded to others in the regular way, and, after taking away gold to the value of several million francs, only retired before a regiment of Cossacks. The same thing is all the more likely to occur in countries under an ill-defined government, of which the famous Brazilian Contesté furnished a memorable example. In this region, situated on the frontiers of French Guiana and Brazil, placers were found towards 1890 of exceptional richness, which yielded a considerable output for several years without any kind of supervision, and the gold produced was included in no statistics. Everybody knows that

in the Guianas themselves a similar occurrence takes place every day on a smaller scale, the gold extracted in the French part being kept from passing through Cayenne, where it would be checked and would pay a tax called the "statistical tax."

The general observation which I have more than once repeated upon the ordinary position of rich discoveries of gold in new countries rebellious to the influence of civilization and difficult of access gives a special value to this remark upon the unknown or concealed output of the placers. It is but too evident that at the moment of the discovery of the Californian placers, or, more recently, of those on the Yukon, the adventurers, who flocked to them in thousands, did not make it their first consideration to go and furnish to some official body detailed accounts of the gold which they had extracted for the edification of economists.

Beside so considerable a cause of error, another source of inaccuracy, of which a word must nevertheless be said, is very unimportant. The gold obtained in the refining factories does not only come from properly so-called gold ores, and does not reach the refiners entirely in the crude form of 750, 800, or 900 per mille fine. Account must also be taken of the traces of gold which exist in a certain number of metals such as copper and silver, and which often do not figure in the contracts for the sale of these metals, or only figure at a price far below their real value. Although it may at first sight appear astonishing, very many mines have long been producing gold

without profiting by it; they sell copper ores, cupreous masses or cemented copper, argentiferous galenas or unrefined lead, iron pyrites, etc., without considering that these products contain appreciable traces of gold, or at least, if analysis has revealed them, without succeeding in getting allowance made for them in the contracts. This is one of the profits, which is often not inconsiderable, of the founders and the refiners. The result is that gold suddenly appears in the metallurgical statistics which had never figured in any mining statistics, and that an output of gold, sometimes supposed to be indigenous, is found attributed to countries where in reality not a grain of gold is extracted from the earth. In particular, this was for some time the case in Germany, where till 1894 the official statistics returned every year 3 to 4 tons of reputed indigenous gold besides the gold extracted from imported ores. The same occurs both in France and in England.[1] But when this error is corrected for the countries in which this gold is obtained, we are confronted by an error on the other side for the world's output, since this gold, which has had to be subtracted from the output of the European countries, does not figure, as it should, in that of the country of its origin.

Taking all these facts into consideration, we see that the official figures for mining returns represent in all likelihood a minimum which is very perceptibly below the real total. They are supplemented in a

[1] I mentioned above, p. 124, note 1, the similar dispute which recently arose over the Hungarian gold output.

certain measure by the accounts of the Customs Houses and mints. It is through the Customs Houses that we try to arrive at the output of China in particular, by calculating the amount exported to England and India and multiplying these exportations by a wholly arbitrary figure. The Customs House returns, on which we also rely for information as to the movements of cash from one country to another, are becoming a more and more insufficient and erroneous basis of calculation, in proportion as they tend in the course of years to affect forms of greater exactitude. The figures which are obtained by such administrative control must always be looked on as minima, especially for the exportation of gold, since it is to the advantage of commerce to diminish its amount. The Italian Ministry of Commerce, having conceived the idea of obtaining statistics based on information supplied by the institutions of credit and the great transport companies, found, on this head alone, the figure for gold to be three times that returned by the Customs. Besides, the facility for travelling, the security of transport, and the multiplicity of exchanges enable a very important proportion of gold to travel *incognito*. To get an idea of this it is enough to try to calculate the amount of gold that may annually enter countries such as Switzerland, Italy, or France, where the traffic is considerable and incessant, in the purses of travellers. The same is the case with the gold that prospectors may bring from distant countries where they have been to find it. Leaving out all question of fraud, there is every reason for concealing

gold, in order to avoid the chance of theft, and every opportunity for successful concealment.

The mints, then, remain. All gold which is to be converted into money and to receive the legal stamp necessarily finds its way to these at one time or another after a voyage of greater or less length. A very good method of investigation would therefore be to count the money coined, on condition, be it understood, of extending the calculations over a fairly long period, if it were not that gold has industrial uses, the whole importance of which I shall presently explain, and which introduce inextricable confusion into these attempts at evaluation. In fact, the cost of coining is so insignificant, and the profit upon the standard of certain ancient coins, or some other such commercial consideration, so often counterbalances it, that certainly a considerable portion of the gold employed by the goldsmiths comes not from ingots, but from coins melted down; and, inversely, gold ornaments that have become old-fashioned, spoiled, or worn may some day or other return to be converted into coins. We seem to obtain proof of this when we compare, as we shall soon do,[1] the world's output with the coinage for a given, and even a very long, period. In the course of the nineteenth century the coinage of gold at least equalled the gold output as returned in the statistics. As the industrial consumption was very considerable during the same time—over 30 per cent. and, according to very plausible calculations, perhaps 60 per cent. of the total

[1] *V.* p. 181.

produced—we must conclude, on the one hand, that numerous gold ornaments, or ancient coins, in which case what we shall further on call their "rate of survival" is diminished, or jewels returned from those countries of the Far East to which there was formerly such a prolonged drainage, were melted down; on the other hand, that there is very probably an increment to be applied to the statistics, which we are again led in this way to consider as representing a minimum.

§ 2. *General notions on the commercial aspect of gold.*

Gold is a commodity, although we are too apt to forget this fact; a commodity which, like all others, is an article of commerce, and which is subject to the fluctuations resulting from supply and demand. Let us, then, take gold as it leaves the works near the mine where it has been produced, and let us try to follow its history. The gold of the mines is always sold in the crude state of *bullion*. This is done even in the countries where there is a great and highly organized industry, as in the Transvaal, and it is still more necessarily the case in regions where civilization is as yet incomplete. The mine owners have several reasons for not themselves conducting the process of refining, which would transform this crude gold into fine gold, by eliminating its impurities. There is, for instance, the difficulty of bringing it to the exact standard required by the mints, the desire to avoid having to watch too long over such a valuable commodity in places invariably more or less isolated, etc. This crude gold is, as a rule, sold

to a local bank, which buys it at a price depending on the percentage of fine gold contained, and it is then passed on under analogous conditions to the refiner in Europe or North America. The refiner in his turn sells it either to the public for its industrial needs, or to the mints or the national banks, the latter buying the gold like the mints at mint price, but paying for it in ready money.

It is only in Russia that these operations are simplified. There the trade in gold is monopolized by the State, to which every one is compelled to sell all his output, and is paid in paper roubles at the current price, *minus* a commission charged on the crude product which varies from 3 to 15 per cent. according to the place of production.

With the exception of this very special case, what happens is usually this: the intermediary bank, which has charged for expenses of commission, freight, transport, and insurance about 1½ or 2 per cent., sells its gold to the refiner at a price which may show between different times a variation of nearly 1 per cent. For example, at London it may vary from £3 17*s.* 9*d.* or 97*f.* 20*c.* the ounce troy to £3 18*s.* 6*d.* or 98*f.* 10*c.* when gold is in great demand and at a premium over the bank note. Besides this question of supply and demand, the quality of the gold also furnishes a cause for variation. Thus, in the Transvaal the buyers of gold produced by cyaniding deducted up to 1895 15 per 1,000 of the value for the inferior quality, and still deduct from 2 to 5 per 1,000. All these considerations, to which, perhaps, should be

added the profit on the declared percentage of fine gold, cause gold to be always much in demand, first with the banks, then with the refiners; they contribute to the result that this special commodity, in spite of its enormous production, finds, as a rule, a very easy outlet.

If we leave on one side these variations of rate, the price of gold is determined in every country by the legal currency of that country, and it is round the point fixed by this legal currency that it oscillates between limits really very narrow, though wide enough to allow of considerable profits, in view of the large scale on which operations are conducted. The peculiar feature, as I have frequently repeated, which at once characterizes the trade in gold is that its market price is almost constant from one country to another, and, moreover, that it does not seem to vary directly with different epochs in the same country. Of course this fixity must not be exaggerated, and we must not only avoid losing sight of its variations at different times, which are none the less perceptible for being represented indirectly by the general rise or fall in the cost of living, but also of the differences from country to country, which constitute an agio. This demand for gold coin is not unlimited more than for any other commodity, and the illusion which exists on this point is chiefly due to the fact that this demand has for a long time been overabundant. But a country has no need to possess more than a certain quantity of ready money. Economists noticed long ago that one gets a very false idea of a nation's wealth if it is reckoned

only by the stock of ready money. There are even countries—a point to which we shall return in speaking of currency—which, so far from seeking to attract gold, have tried either permanently or for the moment to keep it away; and we have recently seen Mexico, formerly the great champion of silver currency, then converted to gold, obliged to defend herself against a depreciation of gold.

In every particular instance money-changers and bankers have to make calculations to find out if it is better, to take an example, to pay London in ingots, napoleons, or pounds sterling.

An ingot, on being brought to a mint or a bank like the Bank of France or the Bank of England, is quoted in fine gold, after foreign metals have been deducted. In France the legal value or *mint price* of gold results from the law of 17 Germinal, year XI., which enacts that from a kilogramme (2·67 lb. troy) of gold $\frac{900}{1000}$ fine there are to be struck 155 pieces of 20 francs. A kilogramme of gold, at the coinage standard of $\frac{900}{1000}$, is therefore legally worth 3,100 francs (£124). A kilogramme of fine gold is consequently worth 3,444*f.* 44*c.* (£137 15*s.* 5*d*), or 15½ times the theoretic value of silver in France, which is 1 franc for 68 grains of fine silver, or 222*f.* 22*c.* (£8 17*s.* 9*d.*) a kilogramme of fine silver. But, since ingots are bought with specie, that is to say, by changing them for other ingots previously converted into coin, it is necessary, in order to get the real mint price, to deduct the expenses of coinage, or 7*f.* 44*c.* (about 6*s.*) a kilogramme of fine gold, which

brings the mint price to 3,437 francs (£137 9*s.* 7*d.*) Without reflection, one might imagine that on payment in coin allowance ought to be further made for the alloy in the coin, in which there is only $\frac{900}{1000}$ fine gold; but this factor has already been taken into consideration in fixing the value of a 20-franc piece, which is 20 francs' worth of gold and not the quantity of fine gold corresponding to its total weight.

Ingots, then, are paid in French currency at the legal rate of 3,437 francs the kilogramme of fine gold. In other countries expenses of coinage and conditions of purchase may be slightly different; we have already seen an instance of this in the case of Russia. In England the Bank makes no charge for coinage, but retains 1·60 per 1,000 as commission.

Gold currency circulates from one country to another because it is the principal (though by no means the sole) instrument of international exchange. The sale and purchase of these gold currencies constitutes the ordinary business of the changers. The precious metals pass and repass the frontiers, increasing or decreasing in price in a given country (and this independently of all the general causes by which the purchasing power of gold may be modified) in the manner of short or long paper, and under the influence of the same causes, namely, the comparative rate of discount and the position of the international balance.

In most countries the legal weight of the currency is determined, as we have just seen in the case of France, by the number of monetary units

which are struck from a given weight of metal. From this is found the relation of one currency to another in respect of the mint price (called in England the mint par).[1] For instance (in terms of French money) the mint par of the pound sterling is 25·221, of the dollar 5·1825, and of the mark 1·2346. Practically, gold currencies are subject to a daily quotation and to fluctuations like the bills of one place upon another and the official foreign discount. For instance, the pound sterling will be quoted one day at 25·05 or 25·10 instead of 25·22, this being for small sales, while for large purchases a certain currency will be quoted so many thousandths above the prices on the tariff of the Bank of France. This is the basis of all the operations of exchange, which form a special science into which we have no need to enter. It will be sufficient to indicate its consequence upon the flow of precious metals.

Let us suppose that Paris has to pay London. She can do so in English sovereigns, ingots, French 20-franc pieces, or paper. If she possesses sovereigns and sends them, she has only to add to their value the cost of transport at 1½ per 1,000. If she sends ingots or French money, since the English creditor is not bound to accept them, the commission charged by the Bank of England for coinage must be added. French gold pieces have a higher standard than the English, but, on the other hand, being bought by weight they lose by wear. Instead of gold she may buy paper on

[1] The parenthesis is mine. The French use the same word *pair* to denote mint price and mint par. (Translator.)

London. This last operation will be advantageous or the reverse according as the rate of exchange is above or below a point easy to calculate from these observations—a point of 25·258 in the case of sovereigns, 25·30 in the case of ingots, and 25·287 in the case of 20-franc pieces. These are what are called "gold points." When the exchange is above the mint par, and consequently an exportation of cash is at hand, it is the custom by virtue of erroneous ancient theories on the balance of trade to say that the exchange is "unfavourable"; it is "favourable" in the opposite case.

When a flow of gold takes place towards any country owing to the exchange, the currency of that country is the first to appear at the frontiers, then ingots, and finally foreign money. In France ingots and part of the foreign money go to the Bank of France, which practically keeps them all, because by paying for gold at the same rate as coin it can pay ready money, and not, like the Mint, after ten days *plus* several days for assaying. In the majority of cases the Bank, being able to represent its gold in hand by bank notes, has the advantage of not paying the cost of coinage, that is, of not really having to coin. It merely keeps these pieces of gold till it finds a favourable occasion to resell them.

§ 3.—*The industrial uses of gold.*

In considering the precious metals, gold and silver, the only use of which we think at first, or at least the only essential use, is for currency, and it is from the

coinage, from the plethora or scarcity of coin, that we reason almost exclusively in order to arrive at the economic position of gold or silver. Thus we forget the industrial uses, which nevertheless consume considerable quantities of these two metals. I, on the other hand, shall begin with the employment of gold in industry, and afterwards return to currency.

The special qualities which make gold so suitable for industrial uses are well known, and some of these qualities have also caused its selection for purposes of coinage. Gold is brilliant, malleable, ductile, almost unalterable and more dense than all the common metals except platinum; it has but one defect (besides its rarity), that it is not hard enough. As we know, this is remedied by alloying it with copper. Nevertheless, gold wears out very quickly, and this "wear,"[1] as it is called, together with accidental losses, which are not to be neglected, helps to cause the disappearance of a large proportion of the gold extracted every year and consequently to reduce the stock of precious metal, which one might have supposed to be incessantly increased by the annual output.

The industrial consumption of gold consists in the manufacture of jewels, rings, watch cases and watch chains, gold leaf for gilding and its use in various industries, spectacle making, pen making, dentistry, chemical and photographic works, etc. Beaten gold leaf is used for the gilded letters of signs, for lettering on book bindings and for book edges, for looking-glass frames and picture frames, and for gilding metals

[1] *V.* below, p. 177.

(bronze statues and iron gratings); gold dust is used on the mouldings of furniture or room decorations, and the Japanese introduce it into their lacquers. Gilding by dipping or electrolysis is another use of gold; it is wire-drawn for shoulder knots and gold lace. It is unnecessary to say that in all these cases alloys and "similor" are freely used.

Attempts have often been made to calculate the amount used in these industries, but they have the defect of attaining very discordant results. The fact is that the gold used by the goldsmiths is not only what they may buy in ingots at the mints, on which statistics have some hold, but also what they obtain by the much more simple process of melting down old jewels and coins or burning old gildings and cloth of gold, and this is impossible to estimate. In an attempt made in 1890, M. Suess[1] estimated the quantity of gold used for industry in the United States at 22·6 tons (or nearly £3,120,000) a year. For the same year he calculated that Switzerland, with its great watch-making industry, might have used 10 tons of fine gold, $\frac{1}{5}$ for watch-making and $\frac{4}{5}$ for jewellery. The consumption of gold in England was valued at about 20 tons, of which 12 were used in Birmingham alone; that of Germany at 15 or 16 tons; and that of France at nearly the same amount. In all, for Europe and North America, the amount of not less than 80 tons of gold was reached, as against the output of the world, which was at that time 181 tons. The same year India had imported 41 tons of gold,

[1] *Die Zukunft des Silbers*, p. 98.

which was used for jewellery instead of being coined. If we add the consumption of other countries, particularly of the rest of Asia, where a great deal of gold is used for making ornaments and where gold is accumulated in hoards, according to primeval custom, we arrive at the unforeseen conclusion (which, it must be stated, has been contested as very exaggerated by other economists) that the industrial consumption of gold may take up 60 or even 70 per cent. of the output.

In 1886 Dr. Soetbeer computed in the same way that in the principal civilized countries 110 tons of gold were used in industry against an output of 160 tons, or 68 per cent. Some years later, according to the Mint Bureau in the United States, there was an annual consumption of 140 tons from 1890 to 1900, or 1,400 tons in ten years against 3,000 tons produced (of which 300 were reckoned to come from melting down old materials), that is 40 to 46 per cent., according as we do or do not include the materials melted down, part of which, at least, was in the form of coins.[1]

Without having had recourse to these latter statistics, it might have been foreseen that the industrial consumption for several years past would have been

[1] In certain books on political economy, I know not why, the industrial consumption has been compared, not to the output, but to the amount coined (which is very variable) in corresponding years. As this amount has been very considerable in the last quarter of a century, we thus arrive at an industrial consumption of 27 to 35 per cent. against 65 to 73 per cent. for coinage. When we add up all the figures representing on the one hand the industrial consumption, and on the other the amount coined, taking each series by itself, we find for the same period a total strangely in excess over the output as returned in the statistics.

absorbing a decreasing proportion of the output which has risen to such enormous figures. Yet this consumption also shows unmistakeable signs of increase; the advance of prosperity and the democratization of luxury, which is so clearly indicated by the diamond trade, are sufficient evidence of this. It is, therefore, probably not an exaggeration to count on an industrial consumption, in an average year, amounting to 50 or at least 40 per cent. of the output.

According to a calculation which is already several years old, but which, having no other aim than to fix the proportions in order of magnitude, is not particularly likely to have become more inaccurate than it was, the annual output of gold was divided in the following manner, which rather reduces the part taken by industrial uses below its real proportions:—

Industry	Jewellery ...	24	40 per cent.
	Watch cases	10	
	Gold leaf ...	2·25	
	Watch chains	1·75	
	Plate	·75	
	Various; pens, dentistry, chemical works, etc.	1·25	
Coinage		44	per cent.
Exportation to the East and loss		16	,,

We shall return later to the proportion here admitted for coinage purposes, and I shall then discuss the proportion of 44 per cent. which has just been given. But before leaving the industrial uses of gold we must say one word about a natural cause which combines with these uses to reduce the world's stock of gold. I refer to the wearing out, the alteration and the loss of gold.

The wear[1] of gold money, of which those who are not specially interested in banking or money-changing do not always think, is far from being negligible. It was possible to observe it in France after the period 1880-85, when the coining of gold was completely suspended, there being a sufficient quantity of gold in circulation, and also from 1886-94, when the amount coined was very small. Experiments made in 1895 showed that the average weight of 155 20-franc pieces, which should have weighed exactly 1 kilogramme, had gone down to 996·6 grammes, of which ½ gramme per mille was lost in the last four years, or 1 per mille in eight years. It has also been observed that a silver 5-franc piece loses, on an average, 4 milligrammes a year, or ·16 per mille of its value.

§ 4.—*Gold currency and bimetallism—The proportion of gold used for currency—Systems of fiduciary circulation—The stocks of coin in various countries.*

One of the principal uses of gold is for currency. Gold, usually mixed with copper in the proportion of 9 to 1, is struck in the mints and circulates with a legal stamp upon it, which guarantees its standard. It is the customary, if not necessary, instrument of all international exchanges.

THE PROPORTION OF GOLD USED FOR CURRENCY.—To what extent does employment for currency absorb the annual output of gold? The proportion, which we have just put at 44 per cent. and which other authors

[1] There is no specially technical word for this answering to the French *frai*, which is only used of money. (Translator.)

put at 60 or 70 per cent., might, it seems, run to 100 per cent., if the public found advantage in it, owing to an immediately perceptible depreciation of gold ingots, since in most of the large countries the coining of gold is free and unlimited. But in reality it is with this somewhat special use as with all the other uses to which any commodity may lend itself, these uses compete against one another. Competition is set up, in which each of them is disposed to pay a fixed price which seems to it to correspond with the advantages which it expects. The price of the commodity rises or falls according as these uses are more or less numerous and their needs more or less pressing. If it tends to rise, certain uses decrease or disappear; inversely, new uses are created if the price descends, and finally the commodity is distributed among its various uses in proportions directly regulated by a body of natural laws. There is no difference in this distribution when the use for currency, as in the case of gold, is placed in competition with the industrial uses, though the variation in price, as regards gold currency, is only felt indirectly and with a certain delay due to inertia.

It is in this way that at different times the proportion of gold applied on the one hand to coinage, and on the other to the totality of industrial uses, may vary very perceptibly, just as the respective proportions of the different industrial uses vary among themselves. An age like our own, in which all countries are adopting in turn the gold standard and excluding its ancient companion silver, evidently presents an example of

abnormal use for currency. If, on the contrary, coining were to be suspended in the principal countries owing to a too rapid influx of gold, like that which took place from 1850 to 1860, the anomaly would occur in the other direction. We have just now admitted a mean proportion of 44 per cent. for purposes of currency. This figure, as may be judged by the preceding remark, represents no fixed proportion, but only an approximate average for the last half-century. It is a long way below that which is held by many economists, and 70 per cent. is far more often given, which shows how far opinions on this subject may vary and how deficient we are in definite information.

There are, in fact, two immediate ways of determining this proportion, which lead to totally different results owing to errors concealed in the statistics upon which we argue.[1] We may, as we have just now done, estimate the industrial uses, reduce them in a somewhat arbitrary degree to allow for the vicious circle in which we necessarily turn, and, as we know, or think we know, the amount of the world's output, calculate the amount coined by subtraction. On the other hand we may start from the real amount coined, compare it with the same output, and evaluate the industrial uses by subtraction. The results are discordant because in fact, as one may easily conceive, the sum of the figures relative to industry and currency,

[1] There is another method, it would seem, namely, to estimate directly the industrial uses and the amount coined, and by adding them up to rectify the figures for the output. But we should then fall into a more serious error of another kind by neglecting the double uses, melting down, etc.

each estimated separately, gives a total far above the returned output.

In face of this difficulty it would at first sight seem more logical to take as our starting point the gold coined, the amount of which is very exactly known, rather than the industrial uses, the figures for which are largely hypothetical. But, while these industrial uses are left to the course of natural evolution and represent, if not a constant, at least a variable bound by a continuous function, the monetary uses remain at the mercy of a law, a decree or a political measure, which completely modifies them. One is never sure, with them, of not fixing upon an exceptional period. A sufficiently long period is then necessary really to strike an average, and yet, after reasoning, for example, from the results of a whole century, we arrive, as we shall see, at impossibilities. It is admitted, for instance, that from 1817 to 1850 England alone absorbed more than the world's annual output to maintain and increase her stock of money. Then came a period of enormous gold production with the discoveries in California and Australia. But, when we take the period of 14 years from 1877 to 1892, we see that in the different countries gold coinage to the value of 360 millions was struck as against an output of 320 millions in round numbers. The same is the case, in a less degree, if we consider the longer period of 1873 to 1904, though it includes our recent large outputs of gold. The amount of gold coinage struck in the world during this period is estimated in the reports of the Controller of the Mint in the United States at

about 1370·4 millions, allowing as far as possible for the recoinage which is always undergone by a certain number of ancient coins. The output during the same period was only 9,295 tons, or rather over 1,200 millions.

The amount coined is divided between the various countries (gross amounts without allowance for recoinage) in the following manner.

	Millions.
United States [1]	368·80
Russia	222·76
Australasia	196·00
Germany	180·24
Great Britain	149·60
France	86·08
Austria-Hungary	60·80
Spain	44·00
Japan	36·96
Belgium	14·56
Scandinavia	11·44
States of South America	9·44
Italy	8·72
Holland	7·28
Mexico	3·92
Portugal	·76
Egypt	·56
British Indies	·24
Gross Total [2]	1412·64

[1] In the United States the total was 2,630,858,645 dollars from 1793 to 1904. The dollar is worth 4*s.* 2*d.* From 1895, when coinage began again at the Paris Mint, till the end of 1905, the quantity of gold in ingots struck at Paris (*minus* recoinage) was not less than 42·36 millions.

[2] The total here, as so often in M. de Launay's figures, does not represent the exact sum of the items, but is taken independently from statistics. (Translator.)

Consequently these two periods, of 33 and 32 years respectively (1817 to 1850 and 1873 to 1904), which one might have thought to be a sufficient length of time to give an average, lead to an apparently altogether paradoxical result: that the consumption (including industrial uses) was greater than the output by one-third, or perhaps by one-half. This paradox weakens but still remains if we also take into consideration the intermediate period. This is the period which succeeded the discoveries in California and Australia, during which the output of gold was for a time superabundant and the coinage slackened or ceased altogether in several countries. In spite of the considerable decrease which results for the coinage in the average year of a century, it is none the less true that, if we had to accept as accurate the various statistics of the output and consumption, it would imply that in the course of the nineteenth century a monetary absorption took place of gold previously accumulated by industry and hoarding, since the output did not suffice to cover the necessary increase of currency.

In reality, the output of gold must be considerably higher than alleged in the statistical returns, and among the various heads of consumption a circular motion must be set up which causes the same precious metal to pass several times over into the calculations the gold of coins being used by the goldsmiths as often as they find it more convenient, and regularly, when the loss resulting from the cost of manufacture is compensated by a too high percentage of gold (as frequently happens in ancient coins), and the jewels

or gilt objects being in their turn melted down to pass into coins.

We shall return to this question again when we speak of the fluctuations in the value of gold, as they are evidently caused by a change in the relation of the two factors of production and consumption, the latter represented by the sum of the uses for industry and currency. But we must first insist upon the monetary *rôle* of gold which is so extensive an element in its consumption.

THE DISAPPEARANCE OF BIMETALLISM.—The use of gold for currency has been becoming more and more general with the increase of international exchanges. The development of these has necessitated a less heavy and cumbrous form of coin than the early copper and later silver money with which gold had originally to compete. As a natural consequence the value of gold relatively to that of silver has increased. At the beginning of the sixteenth century gold was worth eleven times as much as silver; at the end of the eighteenth century the proportion was 15½ to 1; at present, in spite of a gold output of 80 millions, it is between 33 and 35 to 1. In the early years of the nineteenth century England alone possessed enough gold to base her monetary system upon this metal, and when gold began to appear in the provinces of France towards 1850, it was still looked upon with a certain mistrust, so little were people accustomed to it. To-day the gold standard is, *de jure* or *de facto*, practically universal, and, except in

some countries of South America or the Far East, silver money, like that of copper or nickel, is reduced to the rank of small change. What is called the *bimetallic* system, which consisted in fixing a legal relation between the value of gold and silver, while authorizing individuals to have silver coined as well as gold up to a weight fixed by law, has been nearly everywhere abandoned, or at least, in countries which, like France, have theoretically retained it, the free coinage of silver has been practically suppressed.

It is superfluous to follow the steps by which this evolution took place; a few dates will suffice. After England, where the gold standard existed from 1816, and certain minor countries like Brazil (1849), Portugal (1854), and Uruguay (1865), the first of the Great Powers which resolutely entered this path was Germany at the time of her consolidation. It was a favourable opportunity; in any case the monetary system had to be unified, for till that time 66 different types of silver and 17 types of gold money had been in circulation. Advantage was taken of the fact that money was still at about par, and that France was obliged to make enormous remittances for the payment of her war indemnity, to institute the gold standard by the two laws of December 4, 1871, and July 9, 1873. The almost immediate result was to induce the Latin Union to limit in 1873, and in 1878 absolutely to suspend, the issue of 5-franc pieces. At the same time similar measures were taken by the Scandinavian States and the Netherlands (1873 and 1877); then the United States limited the coinage of

dollars (1893 and 1898); Spain prohibited the coinage of 5-peseta pieces (1901); and finally Mexico suppressed the free coinage of piastres (1905).[1] In the meantime, the gold standard had been adopted in 1892 by Austria-Hungary, in 1897 by Japan, in 1899 by Russia, etc. Between 1893 and 1899 British India passed from silver monometallism to a form of bimetallism, which gave it the par of exchange with England while leaving the silver rupee, to which the people were accustomed, as the principal coin. A similar combination, which is likely to lead the races of the Far East to gold currency by a transitional stage, has been adopted for the Philippines and considered for China and Indo-China, which are at present the last refuges of silver monometallism.

This long-standing question of bimetallism is one less of theory than of practice. Bimetallists, without stopping to consider the elements of irrationality, complexity, and artificiality in State intervention to determine the quotation of one precious metal in relation to another, have for a long time strongly insisted on the impossibility of supplying the monetary consumption with a single metal, the scarcity of money which results, and consequently the fall in prices caused by a dearness of money.

In fact, contrarily to the generally admitted principles, it seems, as we shall see, that even in

[1] At this moment, the value of silver relative to gold having slightly increased, Mexico and the other States of South America have been obliged to defend themselves against an exodus of silver by an export tax and by limiting the amount of silver which each traveller may carry away on his person.

a geographically and industrially abnormal period like our own, in which the output of gold will reach a maximum that will perhaps be difficult to attain in a future age, the quantity of gold supplied for circulation seems none the less somewhat insufficient, which implies no change, or if anything a rise, in its value. This phenomenon would manifest itself all the more clearly if this output, as we may expect in another thirty years, were eventually to fall off. And that being so, we might be tempted to agree with the bimetallists, if it were clearly proved, on the one hand, that the need for gold would always be so pressing, and if, on the other, with the generalization of gold as currency, we saw such a very grave inconvenience in a rise in its value, the relation of all the other commodities in the world to one another not being influenced thereby.

FIDUCIARY CIRCULATION.—If gold were one day to be less in demand, we might return to the law of progressive depreciation following increase of stock, which commonly forms part of the economic catechism. There is nothing improbable in this supposition; we shall without doubt witness a time when the needs of the countries newly entered into our type of civilization will be appeased, and when, in addition, we shall make better use of the money at our disposal by causing it to circulate more extensively and more quickly and by making better use of the other forms of credit. There is, at bottom, something rather strange in being in want of gold for

commercial purposes when millions are uselessly resting in the cellars of the banks. No doubt these millions are the security for the notes which replace the gold in circulation, but the bank note, secured by gold, to which men took a long time to accustom themselves, and which is hardly a century old, is already a somewhat archaic form of fiduciary money; and there exist many other means of compensating the movements of purchase and sale, by avoiding those petty payments for which money is particularly necessary and replacing them by a simple process with pen and ink.

For the sake of clearness, let us imagine all the inhabitants of a country with a current account in the same bank. All the purchases and sales which may take place between them will assume the simple form of entries in their debit and credit accounts. The doctor will receive his fee by a cheque passed to his account, and will pay his tailor or his baker by cheques which will be debited to the same account. The system might easily extend to international operations, with the additional use of gold or bank notes to settle the balance.

This is not a fantastic dream of which the realization is in any case very distant. Easily performed experiments have been conducted at various dates to assess on a given day the proportion of notes and gold employed in all the banks of France and Algeria. It was thus observed that in six years, from 1885 to 1891, the relation of notes to gold passed from 2 to 1 to about 4 to 1, the proportion of notes in the total of payments

moving finally from 45 per cent. in the departments distant from the centre to 95·50 per cent. in the Bank of France. This is for the first step, the bank note. The next step, the cheque, which is more recent in France, though it has for some time been in full use in the Anglo-Saxon countries, has also made considerable progress with the extension of certain large banks like the Crédit Lyonnais, the Société Générale, the Comptoir d'Escompte, etc., the branches of which are multiplying in all towns. If thoughtless legislative measures do not momentarily paralyse this forward movement, the time is not far off when current use of the cheque will have penetrated into the country towns and villages, making less and less necessary that accumulation of piles of gold which were formerly considered the supreme expression of wealth and which are really nothing but its concealment.

The deposits and current credit accounts in the great French banks have risen between 1897 and 1904 from 106·4 millions to 174·4 millions. In the United States, between 1889 and 1904, the private deposits (in national banks, private banks, savings banks, etc.) rose from 760 to 2,080 millions. Payments by cheque amounted to 80 per cent. of the total. In England, Ireland, and Scotland, where the use of cheques dates from the middle of the nineteenth century, 800 millions had been reached in 1901, against 520 millions in 1880. In 1887 the payments by cheque in the banks represented 70 per cent. against 30 per cent. for notes and cash together. The Clearing House, which centralizes every evening the debit and

credit paper of the various associated banks, and which cleared 9,360 millions in 1891 without displacing a penny, almost plays the part of that single bank which I was picturing just now.

THE SURVIVAL OF GOLD.—Let us now see what becomes of the gold incessantly obtained by the miners, a considerable proportion of which is coined into money every year, in order to find out whether the durability generally attributed to the precious metal does not suffice to ensure in advance all the money necessary for our future needs.

Whether it has been used by the goldsmiths, or the gilders, or has been coined, it seems, at first sight, that all this gold extracted from the earth accumulates in the visible or concealed reserves of mankind and increases by so much the amount in hand. This has even been made the basis of a theory, according to which gold, ceaselessly increasing in quantity, must proportionately diminish in value; this movement, which is supposed to proceed continuously, undergoing certain periods of acceleration, such as those which followed the great discoveries of the sixteenth and nineteenth centuries.

There is some degree of truth in this observation, and it is clear that gold is not in the ordinary position of a common metal like iron, the price of which is almost wholly determined by the output of the current year or of the immediately preceding years. Gold owes this relative stability of value, which has contributed much to its adoption as money, to its

unalterability and the ease with which it can be recovered by fusion. Yet it would be very inexact to believe that all the gold extracted every year goes, entirely and without any but an insignificant reduction by loss, to increase the previously accumulated stock. In the first place, gold wears out more than one thinks and, being reduced to impalpable dust, disappears for ever from circulation. Let us take simply the wear of coins which are especially well protected against wear by their alloy and against definite loss by the conditions of their use; we have seen that for one kilogramme the wear was half a gramme in four years, or one per mille for every period of eight years. In 8,000 years gold would entirely disappear by wear and tear alone. This wear is, of course, greater in the case of all objects in which gold has been industrially used; and here the element of loss must be added in the form of mislaid, damaged, or cast-off articles, which in the long run must be very perceptible.

So far as coins are concerned, there are certain methods of calculating this continuous disappearance, which is due either to wear and loss, or, more largely, to melting down for industrial purposes, or again to the systematic recasting by the refiners of certain ancient issues in which defective processes have left a few ten-thousandths of gold and a few thousandths of silver too much.

If we go back to the beginning of the modern era, it is estimated that there were not more than 16 millions of gold remaining in Europe. However exaggerated the estimates of the ancient authors may be, this is

evidently a very tiny fraction of the gold extracted and coined up to that time. From 1500 to 1848 636 millions were extracted; from 1848 to 1907 over 1,864 millions. Leaving, then, on one side all the gold obtained in antiquity and lost (perhaps partially to reappear one day), we should have 2,500 millions of gold in hand. Of these 2,500 millions there are certainly not more than 1,200 millions (or half) to be found in the state of coin, while between 1873 and 1904 alone more than 1,360 millions of new gold money were struck. Four hundred millions repose in the cellars of our great banks; to suppose that 800 millions are dispersed among the public, as we shall see, probably means considerably forcing the figures. The remainder, or half the officially registered output, has passed to industrial uses or has been lost.

In France, from 1795 to 1901, 386·80 millions of gold money were struck, a sum which is reduced to 375·84 millions by legalized recoinage. Of these 376 millions, not more than 144 millions, or 38 per cent., have been found by the ingenious methods which we shall now describe.[1]

It is possible, in fact, to set out, to estimate for a given issue of gold money, what has been called its "comparative rate of survival" at the end of several years. This process, applied by M. de Foville in

[1] At present (1907) coinage is very active and yet does not succeed in supplying the needs of circulation. It has been asked whether this is not due to the fact that under the menaces of Socialism everybody is trying more or less to lay by a reserve of gold, to bring in the old "woollen stocking" again, in case of urgent need.

1885, 1891, and 1897, has always given remarkably concordant results, which shows the accuracy of its principle. What it consists in is this. Knowing the amount of each of the successive monetary issues, we class by nationalities and dates all the gold pieces which are in our 20,000 public tills [1] in the same year. If we suppose, on the most favourable hypothesis, that the last issue made still exists entirely in the hands of the public and represents 100 per cent. of the issue, and if, on the other hand, 2·70 per cent. of this issue is found in the tills (31,276 pieces against an issue of 11,652,857), the coefficient which equates the quantity of coins found in the public tills with the total quantity supposed to be still actually in existence is obtained by dividing 100 by 2·70, the result being 37. There should actually exist, therefore, 37 times more pieces of that issue than have been counted in the tills. It is then supposed that approximately the same coefficient may be applied to all the previous issues, and by multiplying by 37, the "coefficient of survival," the proportion between any issue and the number of its pieces counted in the tills, the maximum amount of pieces of the same type which can still exist in circulation is calculated.

Thus, for instance, in 1878, it was seen that 30 to 37 per cent. of issues subsequent to 1830 might be remaining, 15 per cent. of the issues between 1826 and 1829, and 7·5 of the issues between 1797 and 1825. Therefore 92·5 per cent. of the money coined only three-quarters of a century ago has disappeared.

[1] M. de Launay is here describing an actual experiment in France. (Translator.)

The same method was employed to calculate the total gold circulation in France from the money held at a given date in the public tills, by multiplying this latter figure by the coefficient 37, which was obtained from the above experiment. In this way the conclusion was reached that in 1891 the gold circulation in France amounted to 120 millions, and included 35 per cent. of the coins struck in France since 1803, 50 per cent. of the Belgian, 37 per cent. of the Italian, and 33 per cent. of the Austrian coins. Of these 120 millions, 54·56 were then in the Bank of France, and the rest in the hands of the public.

A little later, on the 1st of January, 1895, the gold held by the great national banks of the various countries of the world alone reached a total of 383·04 millions, of which France held 84, Russia 94·92, the United States 39·40, Germany 35·48, England 33·08, and so on. At the same date the stock of money in the whole world was estimated at between 800 and 1,000 millions. In 1897 by the same method the money in circulation in France was found to be 168 millions of gold—an increase of 48 millions on the amount reached in 1891, six years earlier—of which 146·8 millions were in French currency. At present (1907) the amount for France alone is put at about 180 millions, of which from 100 to 116 millions are in the Bank. In England the quantity of gold is much smaller, in spite of a far larger turnover, being only 104 millions according to the most plausible estimates, of which 32·88 are in the Bank of England. The whole system of circulation in England, in fact, is

more logical than that of France, and founded upon the cheque and the clearing house, though this is perhaps pushed to extremes. The State Bank of Russia possesses 96 millions of gold.

§ 5.—*The purchasing power of gold—The fluctuations in its value—The complexity of the problem—Purchasing power measured by cost of living—Comparison with other metals.*

The gold market is subject at every instant to fluctuations which draw the metal from one country to another by means of premium and discount, of which something has already been said. In this or that country gold is more or less in demand, more or less scarce, and stands at a higher or lower price. Like every other commodity, gold rises in price when the demand exceeds the supply. These commercial movements, which begin by showing themselves under the fleeting and usually very limited forms of exchange, discount and premium, when they have reached a certain degree of universality and permanence, end by producing a more serious and lasting effect. When gold perceptibly increases or decreases in value, its purchasing power grows or diminishes, either in a given country the finances of which are less or more prosperous, or in all countries at once by a general phenomenon, and the price of all commodities is modified in consequence. There ensues a period of cheap or dear living with all the resulting social consequences.

As I have already had occasion to remark, the choice of gold as currency has reduced to a minimum an inconvenience which would be far more serious if we were accustomed to estimate the prices of all things in relation to a more alterable substance, on which, consequently, the effect of a slightly larger or smaller annual output would act directly. In the case of gold, the great accumulated stocks perform the work of governors: they diminish the effect of sudden oscillatory motions, but they cannot prevent continuous motions from making themselves felt in the long run. When too little gold is produced for the universal needs, it is inevitable that the price of gold should rise everywhere, as it rises more locally in countries where the exchange has depreciated or the finances are shaken, which have to make large payments of gold outside and cannot succeed in obtaining any. When there is an over-production of gold, on the other hand, its price cannot help falling.

These changes in the value of gold, which are theoretically indisputable, are in practice very difficult to appreciate, and it is especially hard to distinguish them from all the other economic phenomena, the influence of which runs parallel to theirs, in the same or the opposite directions, and with which they are mixed up in an almost inextricable tangle. Some economists have shown an exaggerated tendency to consider the price of gold as the only, or at least the essential, factor in the general movements observed in the prices of raw materials. This is to forget the technical, industrial, scientific, and geological side of

the question, on which I shall presently insist. We start from a very false idea if we imagine that the cost price of manufactured or natural articles is entirely, or almost entirely, determined by the money with which they are paid for. There are other economic considerations which, compared with this, have a far greater importance.

THE COMPLEXITY OF THE PROBLEM.—The present continuous advances in manufacture are indisputable; they are universal, and they act upon all industries in the same direction during periods of great intellectual activity, vigorous industrial competition, and consequently daily progress, like our own. The growing facilities for transport contribute to the same result, as soon as the output has risen to the level of a more widely-spread consumption; and in these there are consequently two important reasons why the price of manufactured articles should fall without an increase in the purchasing power of gold.

Social evolution is likewise a general and highly important factor, which makes itself felt in the opposite direction. The democratic change, so obvious all over the world, has the effect of increasing the price of labour, which doubled between 1840 and 1893. It therefore increases the price of manufactured articles, thus leading to a rise in the cost of living, the weight of which is borne by the working man in his turn, and which incites him to demand new increases of wages. It carries with it, besides, a development of prosperity and even of luxury, which

multiplies the demand for various goods and tends also to increase their price.

Finally, the human population is ceaselessly growing, and its increasing demands lead inevitably to a rise in the price of all substances which cannot be produced in unlimited quantities. For these there is a "vital competition."

These are very wide influences which partially counterbalance the effect of those first mentioned without its being possible, in the one case or the other, to determine exactly in what proportion. In the last thirty years, independently of all force exerted by the purchasing power of gold, two very clear economic facts have been the result: (1) the decrease of manufactures whenever the use for labour is small and the ingenious application of mechanics, physics, or chemistry takes its place; (2) the increase of labour, bringing with it a corresponding rise in prices (with no more profit to the producer) wherever labour is an essential element. In these two cases, as M. Leroy-Beaulieu has pointed out, the predominant factor is the increase in man's power over nature, the share of profit reserved for human effort becoming greater as this effort tends to become more fruitful.

Again, and still independently of the question of gold, we may at once perceive the interference of other more special and temporary factors; for instance, in our day, the transformation of the ancient forms of energy, which were founded on the use of coal, into electrical energy with the growing use of "white coal," and the increasing centralization

of power stations. There is the creation in the country towns and villages of industries and works for providing motor power, lighting, etc. There is the renewal of the machinery in the older large manufactories to give them a more modern form by the use of electricity. This means considerable work for numerous branches of industry—metallurgy, mines, etc.—and, more particularly, has led to the enormous rise which we have just witnessed in copper and lead, the two metals most used in electricity, and these, in their turn, bring all the others up with them. This has also meant an age of fevered speculation, during which the profits realized on a few copper shares or mine holdings have contributed to cause in a more general way a rise in all the Stock Exchange quotations, created unusual needs for capital, and increased, in consequence, the interest on money, while at the same time a rise in all prices was being produced.

So also, the effect of a great war, with its financial drain and with the renewals of material which are its consequence, not only for the countries interested, but also for all the others, which are obliged to make use of the lessons of the latest campaign, is always to cause a movement in trade, which appears as a simultaneous rise in gold and in the most various commodities, the former not being, as a too simple theory would have us believe, contradictory to the latter.

Lastly, periodical cycles of prosperity, crisis, and financial drain have for long been observed, on which

the greater or less output of gold and its diminished or increased value exercise only a very feeble and indirect influence.

But we must, moreover, think of the changes which have taken place in the gold industry itself. The greater facilities for extracting gold from the earth diminish its cost of production, this being estimated in relation to the purchasing power of previously accumulated stocks of gold. They contribute therefore to increasing its output, as similar development would increase that of any other substance, by making possible the intensive working of ancient deposits or the bringing of new deposits into operation and by leading to the utilization of considerable quantities of ores that had till then been rejected and lost as barren. This is a point on which I have already several times insisted. The increased output that results may, theoretically at least, as in the case of any commodity, end in producing a certain state of equilibrium through a more abundant supply of gold, but only after causing fluctuations, to the law of which the general cost of living can furnish no key.

For all these reasons, the problem which consists in determining the oscillations in the value of gold, its scarcity or plethora, is very difficult. If we went by the current doctrine of economists, we should allow that a considerable fall in gold has progressively and continuously been seen, bringing with it a general increase in prices. In favour of this doctrine, moreover, rightly or wrongly, there is a strongly ingrained prejudice. The fact is too widely admitted and seems

so evident that I shall doubtless appear to be upholding a paradox in contesting it so far as the nineteenth century is concerned. Nevertheless, in approaching the problem by different ways we shall see that there is very little proof of the current opinion, even if it is not altogether inaccurate, as we shall tend to maintain. The reasoning of the economists is very disputable in its principle, and as for the common comparison between the present and the past, the "cheapness" of the "good old times" may perhaps, in part, be set beside the exceptional springs, now a thing of the past, which men are said to have enjoyed in the time of Louis Philippe, the "faithful servants" of the time of Mascarille and Crispin, and the marvels of all kinds, the occurrence of which in their youth old men have been accustomed to recall since the days of Horace. Certain heads of expense have increased and others have diminished; people only look at the first, though, in the one case as in the other, contrarily to the classic doctrine of the economists, the influence of the price of gold can only play a very secondary part, masked and disguised as it is by a host of more directly active circumstances.

This does not mean, be it understood, that the purchasing power of gold is invariable, for I remarked on its variability at the outset, and nobody could for a moment maintain that it has not declined on the average in the last hundred years, with periods of acceleration in its fall, such as that which marked the years from 1850 to 1870. But the phenomenon is infinitely less clear, less constant, and less necessarily

destined to become acute in the future than is commonly supposed. A very close examination is indispensable before any assertion is made. We must successfully free ourselves of all the extremely complicated influences which may be exercised by the progress of science and industry, the impetus given to colonization, the transformation of international relations, the evolution of society, the alternating crises of prosperity and atrophy, or even, temporarily, by legislation. When one has thoroughly devoted oneself to this study, one is no longer so very sure that the annual addition alone of a certain stock of new gold to the previous stock must mechanically and automatically, as has often been maintained, lead to a fall in gold, a rise in prices, and a decrease in interest.

If the classic argument were as irrefutable as it may appear at first sight, we may remark that it would equally apply, in a lesser degree, to the majority of other metals. These metals, though more alterable and destructible, nevertheless partly survive their first use, which leaves them at disposal for a fresh use; old platinum, old copper, old tin, old lead, and even old iron are recast like old gold. What is definitely lost, reduced to dust, volatilized or oxidized, is relatively insignificant, and one might then maintain that the price of all metals should itself have a constant tendency to fall. Yet when a movement of this kind manifests itself, it is far more due to progress in mining or metallurgy than to this automatic addition of old to new metal.

In the special case of gold we shall first make use of the variations in the price of common articles and necessaries of life for our examination, according to the ordinarily adopted method[1]; and by this means, as the above observations may have led us to suspect, and contrarily to the general opinion, we shall not arrive at anything very conclusive. In the last century there has been a considerable slump in manufactured articles, which I have just mentioned, and of which modifications in industry are certainly the principal cause, while, inversely, it is to the evolution of society that the rise in wages also mentioned must particularly be attributed. In these two cases it is a matter of some trouble to say what influence could have been exercised by the purchasing power of gold. If we consider natural products, especially vegetable articles of food, in the case of which the two factors foreign to our inquiry most satisfactorily balance one another, though that of labour is left with the upper hand, we find an increase in price, as is maintained by the classic theory of the progressive and irremediable fall of gold, but an increase very small in reality, especially when we compare it with the enormous gold output of our time. According to this method of calculation the price of gold has fallen scarcely 30 per cent., while the amount in hand has at least been quintupled. M. de Foville, taking the average family budgets, has also arrived, as I shall indicate further on,[2] at the conclusion that between 1825 and 1875 the value of

[1] *V.* p. 204.
[2] P. 207.

gold diminished 25 per cent. This figure, which is perhaps too high, and for which many other explanations might easily be given, does not, in any case, bring into prominence that enormous over-production of which people sometimes speak when they wish to find the cause of all our miseries in our too great wealth of gold.

I have tried to apply a different method, which will be expounded later on, by comparing gold directly with the other metals and by applying to it the economic relations which can be perceived, in the most simple cases, between amount of production and value. There is no reason why gold should in this respect behave differently from the other metals. Like them, it is an industrial metal and a commodity, of which, so far as possible, the necessary quantity is extracted, with alternating periods when too much, or not enough, is produced. Just as the output is unconsciously regulated by the demand, so we must be instinctively and inevitably led to pay for gold what it is worth, neither more nor less on the average—the price, that is, which represents the number of its uses and its deposits. Our conclusion will be that, in the present peculiar period in the history of humanity, gold shares the common lot of the majority of metals, possibly in a greater degree than any. Far from there being a perceptible over-production and fall in value, a kind of gold famine may occur in consequence of the enormous and rapidly developed needs of humanity and the breathless but vain efforts of production to keep pace with consumption. By all

appearances we are even now at the beginning of such a change; but up to now, in the course of the nineteenth century, save in the period between 1850 and 1870, gold does not seem to have been over-abundant; rather it has been scarce, and its supply has been particularly insufficient, in spite of the apparent improbability of the assertion, in the last period of ten or fifteen years, though during this time the output has suddenly risen to such giddy heights.

As this theory, I say again, is contrary to the current doctrine, it must needs be discussed. Let us, therefore, in the first place, go back to the classic method of calculation, which has led all writers to hold that the price of gold has progressively fallen, in order that we may determine its value.

THE PURCHASING POWER OF GOLD MEASURED BY COST OF LIVING.—This process, as we know, consists in comparing for different periods the cost of living, the intrinsic value of which is, in the first place, very arbitrarily supposed to be constant independently of its form of payment, in eliminating as far as possible accessory influences, and in explaining the general modifications observed in particular cases by variations in the price of gold.

For this means some (and this is evidently the most logical way) have taken the "average budget" of a family, with the unequal proportions taken in this by the various heads of expenditure, and compared it with similar budgets for twenty-five and fifty years back for an identical scale of living. Others have calculated the

quota of imports and exports per head from the commercial statistics. Or, again, *index numbers* have been employed, which are obtained by taking the arithmetic mean of the prices of a certain number of commodities considered to be the most important. Or, lastly, these *index numbers* have been obtained by calculating, not the arithmetic mean, but a mean proportional, a number being attributed to each commodity according to its importance.

By one or other of these methods, several instances of very marked upward or downward movements are seen in the course of the nineteenth century, and these movements to some extent may be in relation with a change in the laws governing the gold output, though in general (and this is a very important point) they do not seem to feel the reaction set up by this change till after a very noticeable interval.

The most marked and most frequently cited coincidence is that which marks the period between 1850 and 1860, following the really abnormal and exceptional discoveries in California and Australia. A very noticeable rise in all prices was then observed, on which point it must be noted that this period saw the end of the revolutionary troubles which were almost universal in Europe from 1848 to 1850, and the forward movement in industry which was caused by the settlement of this crisis. Estimated at this time in comparison with the other standard, silver, the fall in gold appeared very evident and so disquieting that the banks thought it prudent to defend themselves against an invasion of yellow and a drainage of white metal.

At the same time, according to M. Levasseur, the period 1848-1858 saw the price of corn doubled, that of natural products increase 67 per cent., that of manufactured articles (more directly dependent on scientific and industrial progress) increase 15 per cent., and the mean price of all commodities together rise 41 per cent. Allowing for all the contributory sources of increase, it was thought possible to hold that the genuine fall in gold was 20 per cent.

In the following period up to 1873 the output of gold progressively diminished. This decrease, coinciding with an extension of white civilization over the whole world and with new needs for gold, ought, it seems, on the theory which holds that the value of gold is the supreme influence, to have led to a fall in the price of commodities. Still, without doubt, the gold output of the previous years had not yet become insufficient for the consumption, and the continuation of the industrial development exercised a predominant influence. As it was, though in the exceptional case of manufactured articles this fall really occurred, but owing to many other causes—industrial progress, reduced cost of transport, etc.—natural products, on the other hand, continued to increase in price. According to M. de Foville, the prices of 1873, compared with those of half a century earlier, show a rise of 90 per cent. in the case of animal articles of food, and 30 per cent. in the case of vegetable articles of food. This rise is in contradiction to the movement of the gold output, which here appears as a secondary factor, or at least as an element which had not yet had time

to exert its influence. It is to be attributed rather to the abundance of outlets created by the construction of railways before the production of articles of food could show a corresponding increase.

Nevertheless, if in detail the influence of a more or less abundant stock of gold is not clearly shown, it is thought that it can be traced in a longer period. After eliminating other influences as far as possible, M. de Foville was led to adopt a diminution of 25 per cent. in the purchasing power of money between 1825 and 1875, a period during which the previous stock of gold was nearly tripled—that is to say a period when, if demand and supply had been the only forces at work, and if the demand had remained the same, the price of commodities should have risen nearly 300 per cent.

Then came the period between 1873 and 1887, which was marked by a progressive fall in prices, this time in conformity with the stagnation, or the recoil, of the gold output. Gold appears at this time to have regained a great part of its former purchasing power, which it had lost during the previous fifty years. Here again a multiplicity of causes may have interfered. Easy communication and industrial progress should, in principle, tend to cause a fall in prices, which is only compensated by the increase of population and the advance of its prosperity, if things follow their normal and natural course, without legislative intervention, without artificial frontiers, and without tariff barriers, freely taking, for the output of the whole earth, the common level of communicating

vessels. So long as population has not become superabundant on our planet, there should also be an advantage, so far as cost of production is concerned, in producing each substance at the most favourable points, in order to make the products economically radiate from them over the whole world. Something of this kind must have occurred during the period in question, which was pacific on the whole and saw an increasing facilitation and extension of commercial intercourse. But it is also to be presumed that at the same time gold became really insufficient, especially owing to the abnormal demand caused by the almost universal adoption of the gold standard.

From 1888 onwards the gold output began to rise again with a rapidity (as I have already noticed several times) which had never been known before. Yet the fall in prices for some time steadily continued with a few interruptions (from 1888 to 1890, for instance), thus showing once more the same discordance, at least apparently, between the two phenomena. Perhaps there is here something analogous to what occurred in the other direction during the period between 1860 and 1873; and perhaps it must be admitted that the influence of the great movements of rise and fall in the gold output takes a certain number of years to show itself, just as the effect of rainfalls or snowfalls upon the watersheds is slow, and for the same reason, that the vast interior reservoirs into which the waters are drained and gathered must first be filled or emptied. But, on the other hand, it must not be forgotten that, owing to the unfortunate Boer

war, the real impetus to the gold output was delayed five years and only began with the intensity which might normally have been attributed to it after 1900. We may then partly put down to this high gold output the increase in prices which, while slightly marked after 1898, gained all its intensity in 1905 and 1906.

To sum up, the direct influence of the gold output upon prices seems to have been far less perceptible than that of industrial progress, changes in the means of transport, and alternating crises in financial speculation. This will allow us to maintain, without too much scepticism, the somewhat bold conclusion to which we shall be led by the special comparison of gold, not with the totality of natural and manufactured articles, but only with the other metals which present conditions more logically and more exactly comparable to those under which the evolution of gold takes place.

COMPARISON OF GOLD WITH OTHER METALS.—By studying in this way the output and the price of all the metals, we shall demonstrate generally, and in consequence be able to apply to gold, the very curious economic law to which I have already referred above in passing,[1] according to which, in periods of industrial activity like that through which we are passing, the price of a metal rises or falls with the rise or fall in its output. Instead of the simple play of supply and demand causing, as one might at first suppose, a fall in price, the growing demand leads at one and the

[1] P. 198.

same time to an increase of output and, since the output at first remains, in spite of this, too small for men's needs, to an increase of price. It is only later, when there has been time to discover and begin to work new deposits, that the output first overtakes, and then passes, the consumption, and that a fall in price occurs. On the average, over a fairly long period, the curve representing the output and that representing the price are seen to rise simultaneously, the opposite of what we should at the moment expect to happen.

To show this I have in the following table grouped the outputs of the principal metals for three years taken from a quarter of a century, choosing 1888 as the middle date, as it was, in a way, a characteristic year, preceding, as it did, the great development of the Transvaal gold mines, by which all the conditions of modern industry were influenced. Giving the outputs in tons and classing the metals in order of more or less rapid increase, which is represented by numbers that will be found in the last column, we get the following figures for the world's output:—

—	1880.	1888.	1905.	Number of times increase from 1888 to 1905
	Tons.	Tons.	Tons.	
Gold	160	172	573	3·33
Copper	156,000	263,000	665,000	2·52
Iron, cast iron and steel...	29,000,000	41,000,000	85,000,000	2·12
Lead	303,000	517,000	1,051,000	2·03
Tin	41,000	54,000	105,000	1·93
Zinc	191,000	344,000	608,000	1·76
Silver	2,500	3,700	5,300	1·43
Mercury	3,500	3,900	3,400	·87

In a general way this table at once brings into prominence the enormous impetus given to all the mineral industries in the last quarter of a century. Only two metals form the exception: mercury, the output of which perceptibly decreased, while its price fell owing to a diminution in its metallurgical uses, and silver, the curve of which, after at first rising very rapidly between 1880 and 1895, reached in that year its highest point of 5,600 tons, below which it has constantly fallen since, in spite of a corresponding fal in price caused by its demonetization. On the other hand, in the case of all the other metals, the number by which the output of 1888 must be multiplied to reach that of 1905 varies from 1·76 to 3·66, and is highest in the case of gold. These are the numbers classed in order of decreasing magnitude :

Gold, 3·33 ; copper, 2·52 ; iron, 2·12 ; lead, 2·03 ; tin, 1·93 ; zinc, 1·76 ; silver, 1·43 ; mercury, ·87.

If 1905 had been compared with 1880, the order, in spite of some differences, the chief of which is in the place of iron, would be very much the same :

Copper, 4·26 ; gold, 3·58 ; lead, 3·45 ; zinc, 3·18 ; iron, 2·92 ; tin, 2·55 ; silver, 2·16 ; mercury, ·95.

If we limit ourselves to the last period 1888–1905, the gold output has increased two and a half times faster than that of silver, and is only followed, at a long interval, by that of copper, the industrial uses of which have developed in so marked a way with the advance of electricity.

During the same period the prices of these metals,

classed in the same order, have varied in the following proportion per ton :—

—	1880.	1888.	End of 1906.	Number of times increase 1880-1906.	Number of times increase 1888-1906.
	£	£	£		
Gold ...	137,777·6	137,777·6	137,777·6	1·00	1·00
Copper ...	62 08	54·00	113·20	1·81	2·09
Cast Iron ...	3·72	2·40	3·12	·83	1·30
Lead ...	15·40	14·16	19·00	1·23	1·33
Tin... ...	90·68	116·44	222·80	2·23	1·74
Zinc ...	17·88	16·24	29·80	1·66	1·83
Silver ...	7,680	6,280	4,640	·60	·74
Mercury ...	208·80	260	138	·65	·53

The last column shows the economic fact to which I alluded at the outset, that between 1888 and 1906 the price of many metals, compared with gold, increased almost proportionately to their output, contrarily to what we should have supposed on superficial observation.

Silver and mercury, the output of which has remained stationary or decreased in the last seventeen years, have at the same time fallen in price; copper, the output of which has become two and a half times higher, has, on the other hand, doubled in price; iron and lead, the output of which has doubled, have increased in price in a proportion between 1·30 and 1.

This law can only be very roughly verified, as too many special, temporary, or factitious (syndicates, etc.) circumstances may bring influence to bear; and it is thus that in the case of tin and zinc the increase of price is higher than it ought to be; in the case of platinum, which is still more completely monopolized,

we should find an exception of the same kind. But, on the average, we may conclude that the same causes which lead to a more plentiful demand for a metal and cause an increase in its output also bring about, in periods of prosperity, a rise in price, since the output is not able to keep pace with the too rapid strides of consumption, so that there is a scarcity.

It is not geological or industrial conditions, as one might at first sight suppose, that are the predominant factor in these variations of output and price. In the present state of humanity and with the immense mineral resources at hand over which we temporarily hold rights, practically all the ore necessary is found; the only question is to fix its price, and, short of a complete revolution in the uses of a metal, its price approximately maintains the relation with that of other metals which has been previously determined by similar uses, or this relation varies in a direction which can be foreseen. Demand provokes discovery, at first of too little (whence a rise in price) during the time necessary for prospecting, then of rather too much when this rise has excited emulation too highly, and the output increases with the needs, practically in the degree which this consumption requires. This is to be observed in the case of substances considered rare or exceptional like vanadium, tungsten, cerium, and zirconium, of which no important deposits were supposed to exist till the day when a use was found for them, and then they revealed themselves in quantities before long sufficient, and later over-abundant, for the demand.

If it were permissible to apply so vague and so empirical a law to the precious metal in which we are now interested, we should conclude that the price of gold, without our expecting it, would have nearly doubled, like that of copper, during this last period, and have consequently led to the reduction of the price of raw materials by one-half, its purchasing power having become twice as great.

Since it is possible for this variation to occur without our noticing it in the very prices of the metals on which we have calculated our "increase numbers," it would seem that these numbers should even be further increased and, with them, that also which we have assumed for the analogous case of gold. In fact, an indisputable scarcity of gold is to be noticed in conjunction with the great rise in metals which marked the year 1906, a scarcity which appeared as a general rise in the rate of discount. No doubt it is attributable to other causes as well (the industrial development and increase of speculation in the United States and Germany, etc.), but it leads to the conclusion that the gold output, which has increased so extraordinarily in the last few years, has not yet proved sufficient for the needs arising from the general economic development which took place simultaneously over the whole world.

This conclusion, as we see, is very different to that which is usually maintained and to which the direct observation of the prices of raw materials leads us. But the fact, as I have tried to show, is that in determining the price of materials the purchasing

power of gold is only one of the factors, and not, I think, the chief of them.

In any case it seems permissible to uphold the conclusion to which we have arrived, with very slight variations, by at least three different methods: by the study of the industrial uses of gold and the stocks of money, by the discussion of average family budgets, and by comparison with other metals.[1] If we consider the entire century which has just elapsed (1807–1907), during which nearly 2,000 millions of gold were taken from the earth to be added to the 480 millions which had been previously extracted, that is during which the world's stock of gold was quintupled, it is not possible to say that there was a real over-production. The present gold output is not excessive for our needs. (1) So far as direct observations of currency show, this output only augments the stock of money in a very small degree, which is in no way comparable to the figures which may ostensibly have been obtained by adding successive annual outputs; (2) the influence of an admitted fall in gold upon the cost of living is small, if not imperceptible, and difficult, at all events, to distinguish from all the other influences; (3) comparison with the other metals tends to show not a fall but a rise in gold, which at this time, however, takes a more transitory form in the operations of the great banks.

Thus output may in vain increase and for a moment outrun consumption, for consumption, which grows every day, will soon pick it up, and the

[1] See above, pp. 182 and 207.

superabundance of gold in the world is at all events very far from making itself felt in any disturbing fashion. On the other hand, as soon as a period arrives of high industrial activity, of increased economic relations, and of more vigorous international exchanges, like that which began towards 1905, the supply of gold always fails; it is demanded on all sides, and the general rate of discount rises.

These rules may have momentary exceptions when output increases largely with a sudden jump, as occurred in the sixteenth century or in 1850, and as will doubtless occur again with the considerable outputs which we have a right to expect for the next ten years. But equilibrium is soon re-established, and the demand for gold, which has hitherto always been increasing, is sufficient to absorb the output in spite of its increase.

If this is the case with an annual output of 80 millions, what will happen when the present great deposits are exhausted, and when discoveries fall off, at least for the moment, while through the gradual increase of the human population and its ever rising tendency to employ gold for ornaments and jewels, if not for currency, the consumption is incessantly growing?

§ 6.—*The present evolution of the gold industry—The causes, probable duration and consequences of its development—Economic and political influences on the present development of the production and consumption of gold: Colonial expansion, the Boer war, the penetration of*

China, the abandonment of bimetallism, etc.—The immediate and the more distant prospects of the gold industry—Economic and social consequences—Interest—The future of capital.

The whole question of gold is dominated by an industrial fact of the highest importance, to which I have already several times called attention—the exceptional and unprecedented progress of the present gold industry, to which there corresponds a parallel and equally extraordinary development of the consumption. I shall content myself with giving here, once more, the few figures which make this position clear. The gold output exceeded 80 millions in 1906 as against less than 20 millions in 1884; it has therefore been quadrupled in twenty years, while it is forty times higher than it was 100 years ago (two millions). In the last century, in round numbers, 2,000·millions have been taken from the earth, more than four times the sum of the three preceding centuries. To-day the annual output is very nearly equal to that of the whole sixteenth century and five times the amount which remained in all Europe in the Middle Ages. Finally, if this rate of production continues to increase, as may be expected for a few years, or at least remains stationary, in less than fifteen years a fresh weight of gold, equal to the entire stock of gold to-day existing in the whole world, will be added. There is no need, I think, to insist further upon a position which is clearly so extraordinary. But it is worth while to examine the

causes which have brought about this phenomenon and the permanent or temporary influences which have diminished or corrected its effect, in order to try whether we can approximately foretell its duration. After which, we shall consider the consequences which the continuation of the movement or its arrest at the end of a longer or shorter period may have in the future.

ECONOMICAL AND POLITICAL INFLUENCES ON THE PRESENT DEVELOPMENT OF THE PRODUCTION AND CONSUMPTION OF GOLD.—I have already had occasion to indicate the chief among the causes responsible for the development of the gold industry,[1] which are today the conquest of the earth by colonial expansion and the technical progress in the methods of extraction, which allows of the utilization of ores formerly rejected. But a permanent economic factor also is at work, and perhaps in a higher degree. Besides the deceptive attraction and the more or less comprehensible fascination which this brilliant metal exerts on our minds, the gold industry is very seriously tempting in this respect, that alone among industries it has no need to trouble about the sale of its product. This product flows off (at least apparently) in unlimited quantities and at an unchanging price. There is no element of chance in finding a market, no uncertitude about establishing a gross revenue, and no necessity for commercial organization.

Of course, there is something illusory in all this, for

[1] P. 103.

an over-production of gold, as we have seen, may show itself in a universal rise in prices and, in consequence, an increase in the cost of production. But besides the fact that the influence of this circumstance has up to now been very small, gradual, and confused, it is easier, as we may conceive, for a mine owner to take account in his calculations of the cost, whatever it be, of raw materials and labour, a cost immediately known and subject only to slow fluctuations, than to be obliged to count on the sudden jumps, the "booms" and "crashes," by which the price of every other metal, copper for instance, is suddenly and from day to day modified. The worker of gold has the right, in principle, to count on the certain sale of his commodity, and the economist has only to occupy himself with what will happen when the world is saturated with this precious substance for which the miner for a long time to come is sure to find a market at its legal price without difficulty.

In this connection it should be noticed that the great present needs for gold, on which the gold-mining industry is accustomed to count, are above all the consequence of the conquest of the earth by European civilization and of the closer international relations which demand a common currency. The rapid increase of the output is to a large extent the result of the same phenomenon, the richest gold fields being discovered in the new countries, or brought into operation in the older countries, by reason of the general progress of the country, especially in means of transport or access. It is therefore to be presumed

that, the cause of these two facts being the same, their alteration will take effect almost simultaneously in the same direction: that is to say that when all the countries are gorged with gold, the sensational discoveries of new gold fields will at the same time become more and more rare, and the output will consequently fall just when the consumption is on the point of failing it.

However this may be at a future time, which is without doubt still very far off, the position of gold as the monetary standard, as is well known, is an important factor in its industry, and constitutes an outlet which has been enormous in the last half-century. In this respect a notable change has taken place during the last fifteen years, of which a preceding section will have given some idea.[1]

Between 1890 and 1895 the theory of bimetallism had still many powerful supporters.[2] It has since been very definitely condemned (and will remain so till a momentary rise in silver, caused by its uses for purposes of luxury coincident with large outputs of gold, induces some economist to revive it).[3] In spite of the interruption in the development of the silver output which took place after this time, owing to the depreciation of the white metal (5,292 tons in 1905 against 5,652 in 1895), while the gold output was

[1] See above, p. 184.

[2] I have had occasion to combat it on several occasions in my work *L'Argent*, in an article on *L'avenir géologique de l'or et de l'argent. Conséquences économiques et sociales* (Rev. gén. des Sciences, April 30, 1905), etc.

[3] We have seen that Mexico and Peru are at this time obliged to defend themselves against an exodus of silver.

quadrupled, as we saw, the mean price of silver has barely risen, and that imperceptibly. It too remains practically immobile, with slight oscillations, which in face of the quadrupled gold output is in reality equivalent to a fall. Silver can only really rise again in price through its industrial uses, which, owing to its almost universal abandonment as currency, tend to assume an exclusive importance. But it would also be necessary for its output to remain stationary, as it has remained during the last ten years. If, on the contrary, it were to increase owing to some sensational discovery like that over which much noise is at present being made in the district of Cobalt, in Canada, the relation between gold and silver will show a still larger difference than there is at this time, and we shall see at least an apparent increase in the relative price of gold. Gold then, being more and more generally employed as the universal currency, is more and more in demand, and this movement can only continue by accelerating in virtue of its own velocity till the time when the Far East, which now alone holds out against the gold standard, has been conquered by it.

Two other great political events have had during the last ten years, and continue to exercise, a more or less direct influence on the question of gold in running counter to the normal evolution of its industry, increasing its value at the present moment, and in facilitating its sale. We cannot pass these over in silence.

The first of these events was the conquest of the

Transvaal by the English. This conquest, which the South African financiers had with more or less sincerity demanded, favoured, or encouraged in the pretended interest of their industry, paralysed its development for a long time, as they finally discovered and might very easily have foreseen. In the first place, they witnessed the complete closing of the mines during the two years while the war lasted, which was announced as a simple military excursion, and the destruction of machinery and works (happily very limited) which was the consequence. But the cost of production in particular, which was suddenly to fall one-third with this change of government, remained, taxes included, practically the same at the end of ten years, in spite of all the technical progress made in the interval. In place of the light taxes of the Boer Government, against which such a blustering campaign was conducted, the heavy and costly English administration has had to be paid for, the charges have become heavier,[1] the negroes have lost the habit of working in the mines, and the strangely impracticable idea which was entertained at one time of suddenly reducing their wages by a stroke of authority has led to a scarcity of labour for which the only remedy has been found in the introduction of Chinese labour, which caused, at least in the beginning, a good deal of trouble.

The settlement of the enormous expenses of the war led, at the same time, to a scarcity of capital and a depreciation in securities on the English

[1] The new tax of 10 per cent. on net profit amounted to over £400,000.

market, which were echoed in all the European markets. Then the internal politics of England became vexatiously mixed up with this great industry. This question of Chinese labour, which the Liberal party, on coming into power, intended to forbid, by becoming a subject of political conflict, paralysed all calls for credit, turned away the flow of capital, prevented the rise of new while increasing the cost of the older businesses, and, finally, helped to diminish very considerably the output of gold which the Transvaal should to-day be yielding. By a regular political paradox, the event which was to temper these inconveniences was one that might have aggravated them still more seriously; it was the return to power of the Boers, who, conquered on the field of battle in 1900, regained the control of their country at the beginning of 1907 through their victory in the elections; and the directors of the mines then welcomed with evident satisfaction (February, 1907) the accession to the office of Prime Minister of General Botha, the former leader in the struggle against England, who is to-day too happy to be back in office to free himself from the fantastic and *soi-disant* Liberal ideas by which the English Government might have ruined the mines.

Thus everything has accumulated in the last ten years to hinder the gold industry of the Rand, and it may be said that the value of its gold mines has been reduced one-third or one-fourth by the collective influence of these occurrences. It is assuredly no exaggeration to affirm that the output also has been reduced to two-thirds of what it ought to be; the want

of capital, the scarcity of labour, and the increased cost of production having prevented both the working of a number of recognized deposits and the extraction in the active mines of masses of poor ores which for these reasons fell below the minimum percentage. Through all these causes the Transvaal war, by first diminishing the gold output of the world and then preventing its increasing as much as it should have increased, has falsified for the moment the economic law of evolution which governs the industry of this precious metal. The flow of gold on which we had grown accustomed to reckon failed all of a sudden just when needs for gold were making themselves felt to pay the expenses of the war. Thus we witnessed in 1906 a scarcity of money such as there had not been for fifteen years. The human race, with its annual output of between 60 and 80 millions, was hard up for gold.

Gold therefore rose in value. This appeared, as I shall indicate further on, in an increased rate of interest and a fall in the principal securities, though incidental causes in some cases increased, and in others diminished, the degree of change. But it is to be presumed that we are nearing the end of these difficulties, and if the Transvaal is finally free to develop to the fullest extent, we shall witness during the next ten years an increase in the gold output far higher than that which has been seen hitherto.

The Transvaal war is not the only fact of this kind the effect of which has been felt, or which must exert its influence in a very short time. We have also to

reckon with the rapid transformation of the Far East, resulting from the successive wars of Japan against China, of Europe against the Chinese after the Boxer risings, and finally of Japan against Russia, with the surprising development of Japan and the transformation of China and Japan which may be the consequence. There, too, the immediate result is a need of gold to form the stocks of currency for international use in these countries, which hitherto have kept to silver currency, and to pay for their purchases in Europe.

On the other hand, we may possibly in the future see the discovery of large deposits of gold resulting from the penetration of China and, above all, of Central Asia. But, in principle, it is not the old Asiatic countries of very ancient civilization on which we must count to any extent for future discoveries of gold. Gold is a metal too attractive and too easy to recognize, or even to extract for the superficial deposits, by the discovery of which sudden impetus is given to the output, to have escaped exhaustion in general. With the exception of its central and northern parts, which are still but little known, Asia, like Europe, will only begin again to count seriously in the gold output when, after the free gold of the surface has been almost everywhere extracted, we are reduced to those more permanent forms of deepseated and complex ores which will be the great resource for the future.

To sum up, it is evident from these various considerations (1) that the increase of the gold output, extraordinary as it may appear for the last ten years,

has yet not been what it might have been if the Transvaal had not been subject to the disturbance of the war; (2) that, on the other hand, the needs for gold have been, and will for some time remain, abnormal. Decrease in output and increase of markets necessarily mean a passing rise in value, which, in the case of gold, is hidden by the generality of phenomena of all kinds, in the midst of which the influence of this factor is limited, but it is none the less real, and by the very nature of its causes must be modified, or even has doubtless begun already to be modified since 1904 or 1905, through their progressive disappearance.

THE IMMEDIATE AND THE MORE DISTANT PROSPECTS OF THE GOLD INDUSTRY.—If we consider, to begin with, the immediate future, it is to be presumed that the development of the gold industry will proceed at a great pace for some time longer. Independently of the United States, where the number of workings, though far advanced, is far from its apogee, much remains to be done in this respect over the whole length of the American continent, especially in the ill-explored northern region. The sensational discovery of the Yukon placers has only been an episode in the series of finds which we may expect. Briefly stated, these Yukon gold fields have only produced in ten years a total of 20 millions—an amount produced by the Transvaal in less than a year. But the progress of Canada and Mexico, for instance, which rose, the one from ·20 to 3 millions, and the other from ·24 to

3 millions, between 1893 and 1905, shows, on the one hand, what may be expected from certain regions hitherto considered inaccessible, and, on the other, how much may be yielded by relatively poor forms of sulphuretted or complex ores which exist in great masses in the deeper parts of numerous deposits that are supposed to be exhausted. In South America, Columbia, Bolivia, and Chili practically everything remains to be done. Australia contains many more large and unknown regions to lend to gold discoveries. The Transvaal, which produced 24·8 millions in 1906, will reach 32 millions so soon as the wholly artificial political difficulties cease to hinder the recruitment of labour. Rhodesia is beginning to become important. West Africa is at last yielding a little of what its enthusiasts had been led to hope for. In the rest of Africa, besides the rich ores which have generally caused nothing but disappointment, there seem to exist almost everywhere considerable masses of poor ores, which will assume importance so soon as they can be treated at a smaller cost, or the metals, such as copper, with which the gold is associated can be extracted. Finally, as much can be said for all those auriferous rocks from which come the placers of the Ural Province, Siberia, and Korea. On all sides the impulse has been given, and for at least thirty years we may count on an output of gold higher than, or at least comparable to, that of the last few years.

This is sufficient to cause prophecies relating to a more distant future to lose a great deal of their interest, since most of us have little chance of seeing

them come true. A quarter of a century is, however, a short period in the life of the human race, or even in that of a nation. What will happen later on? Later on, it seems permissible to say, as I have already indicated several times, that the future will be more and more with the poorer ores, the reserves of which are still so considerable. The general law which, in the case of all ores, leads towards the economical working of large, poor masses is already beginning to make itself felt in the case of gold. As we have seen above,[1] the largest gold mine in the whole world is that of Homestake (South Dakota), which, with 900 stamps, annually crushes 1,400,000 tons of ore containing less than 15*s.* 2*d.* a ton. The Treadwell mine in Alaska with 540 stamps crushes 600,000 tons of ore at 8*s.* 4½*d.* a ton. The Rand, which in a narrow district hardly twenty-eight miles long produces more than 24 millions of gold yearly, does so with relatively poor ores, which sometimes contain hardly 24*s.* the ton. In December, 1906, 1,150,000 tons of ore were crushed there to produce 2·356 millions of gold, or 21*s.* a ton.[2] In proportion as the expenses decrease, the mean percentage will correspondingly fall through the utilization of great masses that are valueless to-day.

I am only here speaking, be it understood, of hard ores in the rock which have not been changed or subjected to a preliminary natural concentration, as

[1] Pp. 114 and 117

[2] It must not be forgotten that the mean figures are highly increased by a few rich mines. The mean percentage of ores crushed since the beginning on the Robinson mines was £3 14*s.* 4*d.*, and on the Ferreira mine £3 12*s.*

in the superficial alterations or, more especially, in the alluvia, in the case of which the cost of working is such that with the hydraulic method alluvia have been profitably treated containing hardly 2*d.* or 3*d.* to the cubic yard, and where 2*s.* 4*d.* to the cubic metre (15 grains), or ·00000044 of the weight, is a very paying percentage.

This movement is making itself felt everywhere, but nowhere, perhaps, is it more noticeable than in Mexico, the classic centre of the world's output of silver. We know how the regeneration of Mexico, which began thirty years ago with the establishment of a stable form of government, led, in the first place, to the revival of the silver workings on the poor and deepseated parts of the ancient veins from which in the sixteenth and seventeenth centuries such fabulous riches were drawn. In a few years Mexico with gigantic strides overtook her great neighbour, the United States, in the amount of her silver output. Then came the fall in silver, and Mexico turned her hand to producing gold, searching out the auriferous parts of the same metallized regions; her output of gold, insignificant before 1894, rose rapidly to 2·60 millions in 1904 and 3·24 millions in 1906, which enabled her to abandon the silver standard.

What has happened in the case of Mexico may give us an inkling of what will soon happen in South America, when the advance of Yankee imperialism, hastened by the piercing of the Isthmus of Panama, has reduced the South American Republics to order in the shape of a more or less disguised protectorate.

It is these ancient States of South America that seem destined to a most remarkable development in the near future.

But outside these very rich countries, for which it is easy to prophesy, it is very probable that something similar will be seen in the Old World. Europe and Asia are auriferous countries; antiquity had its Californias, which it knew as the Pactolus and Mount Pangæus, Egypt or the Altai district. In all these countries, not only the alluvia and placers, but also the topmost parts of the lodes, have been removed; the deepseated parts remain, where poor ores exist which are unworkable to-day, but may one day become a source of wealth.

This is also true in the case of regions such as the Rand, where, in an enormous series of strata, so many layers are, strictly speaking, auriferous. The cost of working at a given time, as I have often enough noticed, alone marks the boundary line between what is called ore and what is considered barren, and determines the limiting percentage, below which a rock is rejected. Let us then consider the transformation produced over the whole world by the invention of cyaniding in 1890, and that sudden impetus which, soon afterwards, made the curves of production rise in the United States, Australia, and the Transvaal; let us imagine the similar result which might be brought about by a quite different improvement in industry leading to a reduction of the cost by a few shillings; or let us simply calculate the normal reduction, in the countries where gold is

already worked, resulting from all the improvements caused by this very working, not to mention the covering of expenses of installation, and we see that the future output of gold is likely to be supplied, in quantities that will for a long time suffice for our requirements, by poorer and poorer ores, which, from the very fact of their poverty, will be more and more abundant.

Given the quantities of gold calculated above which are contained in the earth's crust and the seas, there is no reason why we should, strictly speaking, suffer from want of gold, even if our needs for money were not, as they unquestionably will be sooner or later, diminished by the more general use of other instruments of credit. It is a simple question of cost of production, and whether industrial expenses are reduced through scientific progress, as they constantly tend to be reduced, or whether the value of gold increases owing to a beginning of scarcity, we shall find all the gold we can desire in the form of ores which are to-day not utilized.

The future industrial improvements of which I have just spoken, and which it is logical to expect and to reckon in our forecasts, should nevertheless not cause us to forget the natural law by which auriferous deposits are rapidly exhausted owing to the very attraction which they exercise and the exceptional ardour with which they are worked; they should not lead us to neglect that kind of over-production, of a purely geological type, which, as we have seen,[1]

[1] P. 73.

impels men to extract an excessive quantity of gold in comparison with the percentage of gold in the earth.

When we take up, statistics in hand, the history of the great gold-mining districts, we almost always find the same succession of stages which I have already summarized,[1] the romantic phase of enormous output and disorder, with the influx of isolated miners, then technical organization on a large scale, and, lastly, apparent exhaustion and temporary abandonment, when such a depth has been reached that the cost of extraction, exhaustion, etc., make the ores unworkable, or at least discourage the search for their continuation by expensive methods after one or other of those accidents or impoverishments which, from time to time, cause a metalliferous vein to disappear. If, therefore, we wish, in thirty or forty years, to continue the gold output at the same rate of 80 millions a year, it will be necessary, all the present deposits having been exhausted, either to have found others of equal value in the unexplored regions of the globe, or for the more economical treatment of immense quantities of poorer ores to have taken their place. On the supposition that one or other of these two hypotheses is not realized, a relaxation of the gold output will then be observed until the intensity of the needs for gold has again become sufficient to increase the price of gold (thus reducing the cost of production) and to lead to the reopening, which has so constantly occurred in the history of mines, of formerly

[1] Pp. 16 and 98.

abandoned deposits by the application of new and more perfect processes.

But, as I said above, the eventuality of a certain scarcity of gold after such an interval, succeeding a high immediate output, could not in any case have the same economic consequences as if it were to occur at once before our very eyes. At this moment it is probable, in spite of the continuous growth of the population and the advance of luxury in all nations (of which the increasing consumption of diamonds at higher and higher prices is so strange an indication), that the need for coined gold will make itself less hardly felt. In fact, we must suppose that exchanges will be more and more effected by paper, and that the accumulated stock of gold, with the annual additions, will perhaps be just sufficient.

ECONOMIC AND SOCIAL CONSEQUENCES—INTEREST—THE FUTURE OF CAPITAL.—The present period, for fifteen or twenty years more, as we have just indicated, shows every likelihood of being marked by an enormous influx of gold. We may then ask ourselves what may be the consequences of this output, which has risen for several years to at least 80 millions a year, a fifteenth of the whole present stock of money. Is this influx of gold over-production? Will it have the usual consequences of over-production, that is to say a depreciation of the metal produced, which, though it would appear less directly in this case than in that of a common metal, would none the less produce results easy to foresee, the chief of which are a lower rate of

interest and depreciation of superabundant capital together with high prices?[1] As I have said, this does not seem likely, at least till an entire change in conditions, or, if such a phenomenon is beginning to be perceptible, it dates back a very little while. I have already laid sufficient stress on the reasons which forbid us to admit at present any notable diminution in the value of gold similar to that which was caused in 1850 by the discoveries in California and Australia. On the contrary, raw materials continuously fell in price from 1870 to 1890, a fact which, while being evidently due to many other causes (the development of intercourse, facilities for transport, industrial progress, and international commerce), does not seem to be compatible with a diminution in the value of gold; and this is made the more probable since, at the same time, the considerable increase in the price of labour attributable to political or social causes, and the general increase in taxes for the same reasons, have helped to counterbalance these advances.

A very striking economic event took place about ten years ago, in which an indication of a momentary scarcity is rather to be seen. Till that time the rate of interest had for long been undergoing a progressive decrease, which was only interrupted by some disaster such as the war of 1870-1871. It had progressively descended from 5 per cent. to nearly $2\frac{1}{2}$ per cent. for the same class of securities, which was largely due to the growing taste of the public for transferable securities and, in particular, for State loans, which

[1] See above, pp. 194 *seq.*

took the place of land as an investment; yet it also indicated the growing stock of disposable capital. The economists had a very simple theory to explain this continuous fall in gold, which we have already encountered on our way. Gold, they said, being almost irreducible by wear, and its stock increasing with the new output of each year, its value must necessarily decrease, its purchasing power progressively fall, and its interest be reduced.

At that time the politicians, to whom this reduction of interest seemed very convenient to balance future Budgets by conversions of stock, generally agreed to continue these falling curves in thought, and nearly all gave out that this movement would continue without interruption and would gradually be accelerated. Budget committees gave up the ungrateful task of trying to retrench, and opportunist politicians saw in the same phenomenon a panacea for all social ills; the classic dispute between capital and labour was to disappear of itself in the near future by the suppression of all capital not applied to industrial purposes.

However, the economic law, which seemed so firmly established, and which may again become true in the future, bringing with it part of the results that were then prematurely discounted, has just been somewhat contradicted by the facts of the last ten years: the rate of interest, instead of continuing to fall, has risen perceptibly in the case of transferable securities formerly considered "gilt-edged." Here, too, as in all economic phenomena, the causes are complex and sometimes hard to distinguish. It is, however, evident

that the first was the Transvaal war, owing to the expenditure which it occasioned and the interruption of the South African gold output which resulted. Gold, becoming scarce, was more in demand, and consequently lent itself out at a higher rate. A result of the same kind was soon afterwards produced by the Russo-Japanese war, the war loans of the two countries, the destruction due to the Russian revolution, the general reorganization which that great Empire must undergo, and by the renewal of war materials which the cynically provocative attitude of Germany has made necessary all over Europe.

Finally, since 1905, two phenomena of another kind, absolutely independent of each other and even contradictory, have added their influence to these others, and in the same direction. In the first place, we have found ourselves in a remarkably prosperous phase for all industries, one of those phases which return automatically at almost identical intervals, like the swing of a pendulum. A great upward movement, which started in the United States and Germany, pushed most of the industrial securities up to prices which continously increased. The realized or expected profits both incited the lucky investors to expenditure which caused other industries to prosper and created a taste for such remunerative industrial investments which led part of the public away from its former safe investments. Enterprises were launched, there was need for capital, and a higher price was paid for it than before, as in all periods of speculation. In reality, the fall of interest, or, to take an instance,

the rise in the French Rente, which sometimes gladdens politicians, is, as everybody knows, simply a symptom of industrial debility. If the rate of interest falls, it is not so much because there is too much money (for it will be a long time before new enterprises are far to seek), but because the money at disposal is badly employed.

The second phenomenon which has occurred is the arrival in power of the Socialist party in France. The result has at once been that capital, on this open declaration of war upon it, has retreated to foreign investments, where it has found, if not more security, at least higher interest with equal security. For a whole year the French Rente has been sold, and also the railway stock, which formerly showed a continuous tendency to rise, because the custom of the French investor was to replace in the same form part of the realized coupons at every payment of dividend. Not only have all the great French securities at fixed interest been sold to buy securities of other countries, but even in the case of industrial investments intimidated capital has fled outside France, always with the same result of a rise in interest, because interest was nowhere so low as in France. The real value of gold has nothing to do with these movements; but all the causes which, to take our typical investment, produce a fall in the French Rente lead to a general rise of interest, and consequently give a privileged position to accumulated capital The political consequence is curious; for this social conflict, in which capital and labour were supposed to figure, the actual opposition

being rather between those who work and save and those who wish to do neither one nor the other, has the primary result of increasing the importance of capital, which receives a higher interest for its hire. The importance of labour, in certain respects, is thus decreased, for, even with increased wages, it would not really receive more, since the cost of living tends to rise, and its real wages do not in fact increase so much as might be supposed, because capital, driven to expatriate itself from motives of prudence, chiefly profits from the development of foreign industries.

It is easy to see that this result would become still more marked if the present social war took a more acute form. Pushing things to extremes, and supposing a general emigration of capital, national labour would entirely cease to be remunerated, having no further object, and, at the same time, all articles necessary to existence would rise immeasurably in price. We may think that this is an altogether momentary state of affairs and peculiar to France. This belief must not be encouraged, and the evolution, which has taken first effect in France, is likely to become general. Its consequences, as we have just seen, may be as serious, though in a different way, as those resulting from the gold-mining industry.

Leaving on one side these questions, on which discussion remains open and with which we have here to concern ourselves as foreign elements coming in to falsify the direct influence of the gold output, we see many reasons why the rate of interest should not continue to fall so continuously, inevitably, and

indefinitely as was formerly supposed, and why there should not consequently be an immediate superabundance of capital in spite of a very brisk production of gold which in the next fifteen years will throw some 1,200 millions more into circulation. Above all, a transformation in the financial habits of the public is to be foreseen, similar to that which formerly led first the bold, then the prudent, and finally the timid spirits to cease from invariably spending their savings in rounding off a corner of land. But, if only a little more ingenuity and enterprise is shown than in the past, capital, of which gold is both the symbol and the concrete representation, is not yet exposed to the fate of remaining out of employment. We are far from the time when there will be no more of the earth left to be exploited. The field of activity open to enterprises of all kinds, to the development of the means of transport, to the utilization of natural forces, to changes made possible by electricity, etc., is still vast, and for every enterprise gold will be necessary, so long as it remains the means of exchange and universal payment.

Gold, if we reflect upon it, is something like stored up vital force; it is labour, it is energy in the potential state—energy which has been somehow condensed in the little metallic discs by the pains spent in wresting them from the earth; after which, passing from hand to hand, they excite at every move an amount of labour equal to that which was necessary for their acquisition simply as a price paid for the exchange and without losing anything themselves; moreover,

the quicker they circulate, the more labour they produce. There will be need of capital for many generations more, and capital will become more and more international with the unification which cannot fail to ake place in the manufacture, the production, or the cultivation of all articles, so that men will be glad to find in the earth that gold which is precisely the most convenient form of capital for these international transactions. Then there will also be wars for a long time to come to destroy the patient labour of the "industrious ants," and to increase the need for that gold which is required to reconstitute the riches and works of all kinds that have been annihilated in an instant; for many years yet the clumsy or voluntarily brutal attitude of a German Emperor will be enough to cause many millions' worth of unproductive orders for war material to be given in the neighbouring countries.

It seems, then, that the present holders of gold, in the first rank of whom France must be named, will pass without too much injury through this stage of very high, possibly too high, output, the beginning of which we are now witnessing, and which, added to so many other causes, will perhaps produce a rise in the cost of living. But, so far as it is due to the gold industry, this phase of dear living cannot be indefinitely prolonged. It will be followed, as in all phenomena of this kind, by a series of oscillations. When for one moment too much gold has been produced, the cost of extraction having risen, production will cease, the more readily since the rich deposits

of to-day will be exhausted, and men will wait till the need of gold again becomes more pressing before they set to work upon the poorer ores. Equilibrium will therefore be quickly re-established with a fall in the cost of living and will be followed by a momentary scarcity produced by the continuation of the industrial, not to speak of the monetary, demands for gold. After which, in accordance with the sinusoidal law which governs so many economic manifestations, men will again begin to extract the yellow metal, and it will not be found that there are insufficient quantities of gold in the earth; there could not occur, in this respect, a definite gold famine. Gold can never absolutely fail, it is only exposed to a rise in value, since the earth's crust contains much more than the human race could use.

To sum up, if gold cannot really fail, yet we must look forward, in a more or less distant future and independently of previous oscillations, to a probable increase in its cost of production; for, as time goes on, the ores which are found and treated will be poorer and, under similar conditions of treatment, the extraction will be more expensive. To extract a sufficient quantity of gold it will be necessary to make a profit, and, in consequence, if the gold industry has not sufficiently improved, a rise in gold must take place. Not only do we fail to see here any probability of continuous depreciation according to the classic theory of the economists, but, on the contrary, we are even led to hold that in the future a fall in prices and a rise in the rate of interest must necessarily occur,

even if at that time no other forces intervene, in much higher degrees and acting in very different directions, such as a more and more fierce competition between men, a more and more intense struggle for life, the more and more ingenious and complete utilization of natural wealth, the increasing popularization of fiduciary methods of circulation, of transferable investments and deposits at interest, etc., etc.

In spite of all, it seems logically deducible that after an indefinite and perhaps long period the price of gold has more chance of rising than of falling in accordance with the law generally received. It will rise in spite of the industrial progress which will tend to make extraction more economical at a similar percentage, in spite of the growing use of instruments of credit, and in spite of the more and more complete exploration of our globe, because its rich deposits will progressively be exhausted. It will rise in spite of the continuous accumulation of previous outputs, because, if gold only wears out slowly, it can never be renewed, and because the earth only offers us limited concentration to set off against the indefinite reproduction of vegetable and animal substances or of human efforts. The chimerical power of domineering capital, of gold, which for so long has commanded Nature and governed the world, may change hands violently or legally; but, whatever may be said, the time is yet far off when it will vanish into empty smoke, scorned, useless, and despised.

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